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(54) **TWO-WIRE TECHNIQUE FOR INSTALLING HAMMERTOE IMPLANT**

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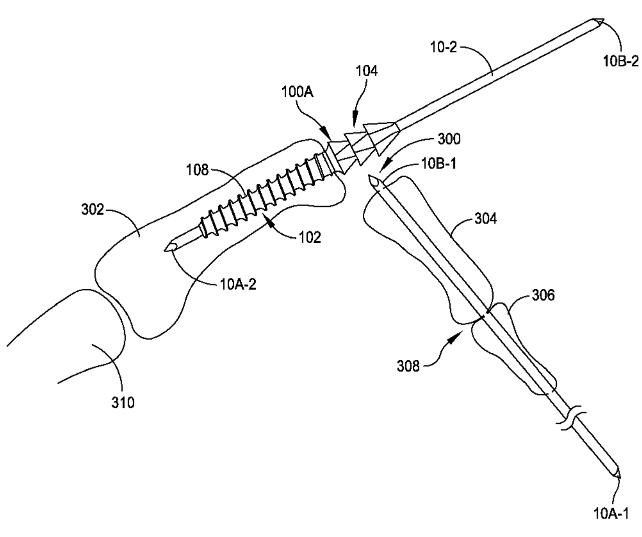
(57) **ABSTRACT**

A method includes inserting a first surgical device into an exposed first end of a first bone until a trailing end of the first surgical device is disposed adjacent to the first end of the first bone. A second surgical device is inserted into an exposed first end of a second bone while the first surgical device remains disposed within the first bone. A first portion of an implant is advanced into the second bone while being engaged with a passageway defined by the implant such that the implant is guided by the second surgical device. The second surgical device is removed from the second bone and from its engagement with the implant. The first bone is repositioned such that the first surgical device is aligned with the passageway defined by the implant, and the first bone is forced into engagement with a second portion of the implant.

16 Claims, 39 Drawing Sheets



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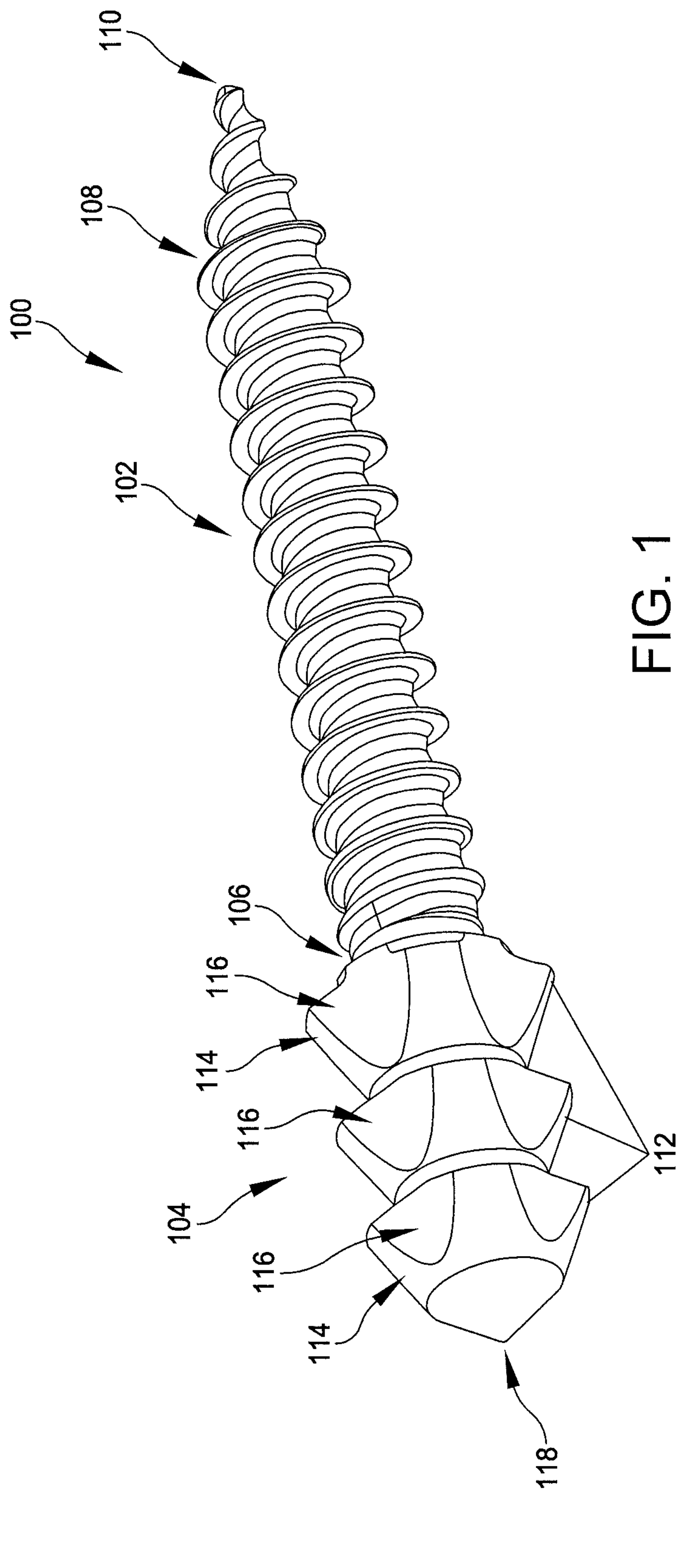

FIG. 1

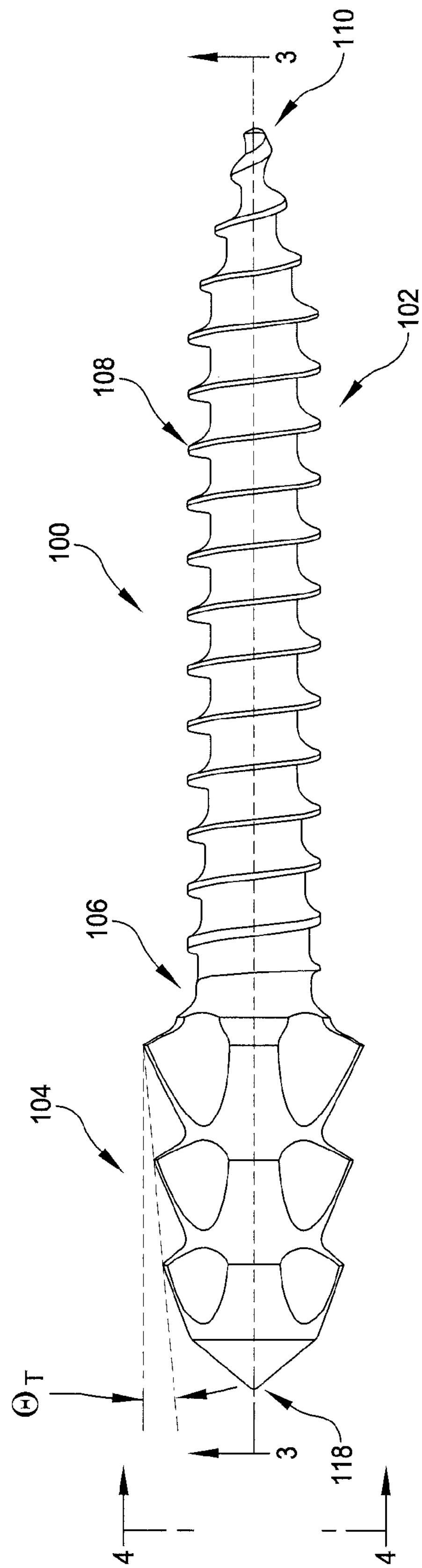

FIG. 2

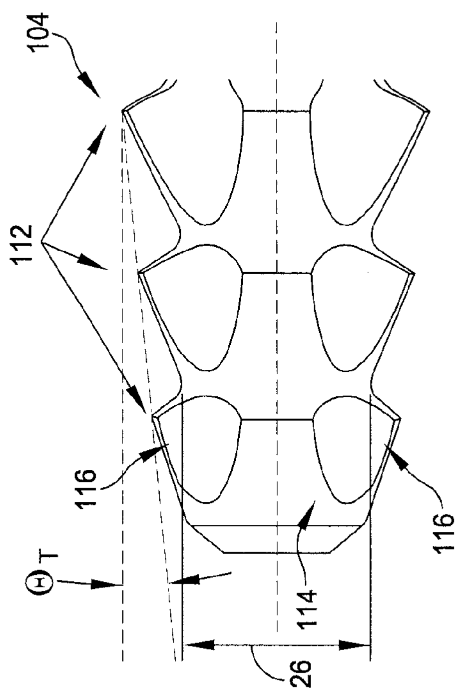

FIG. 3

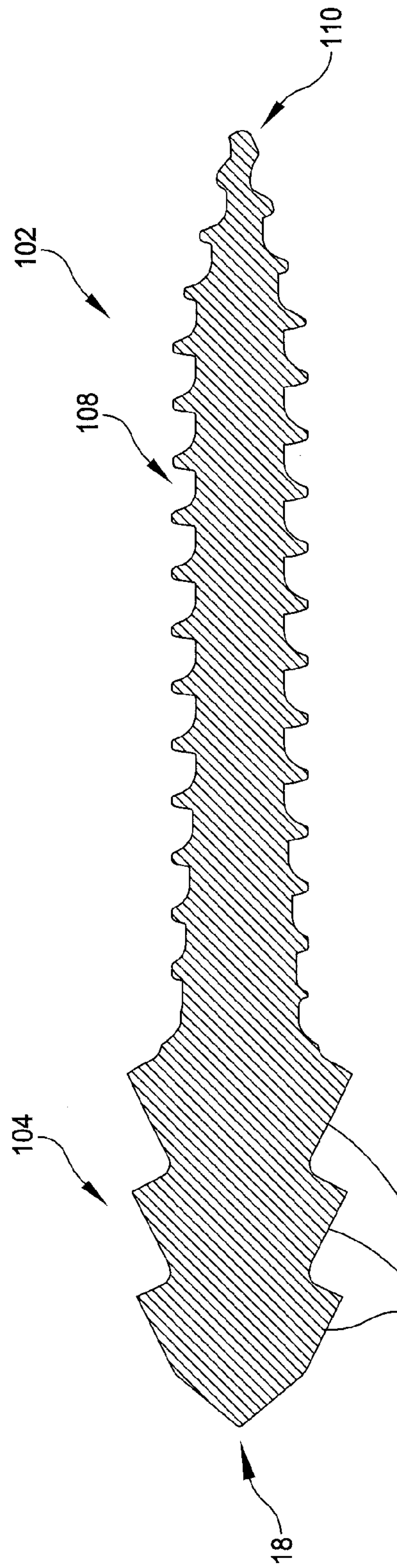

FIG. 4

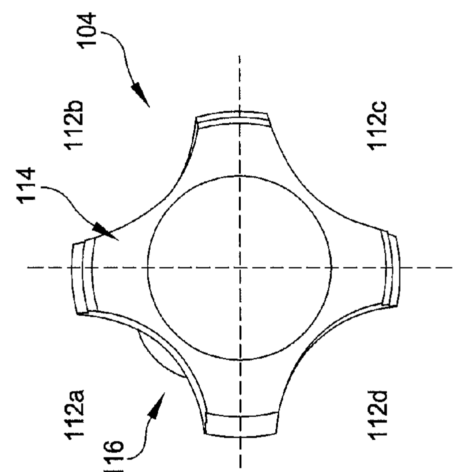

FIG. 5

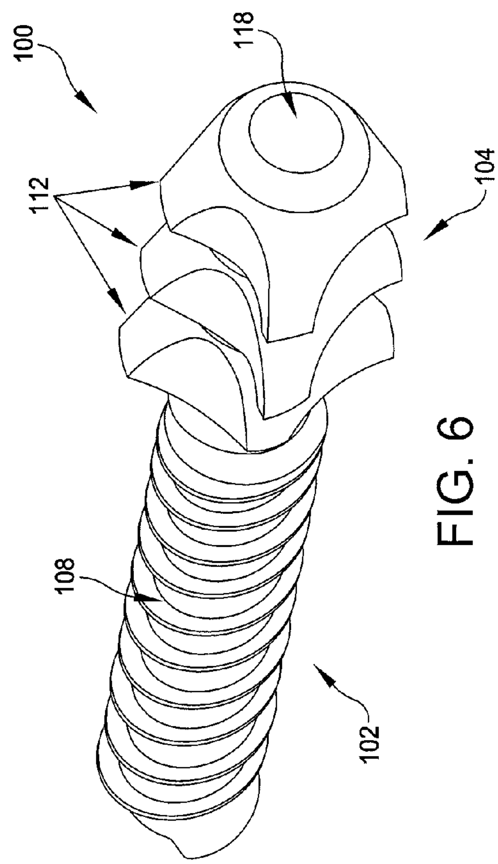

FIG. 6

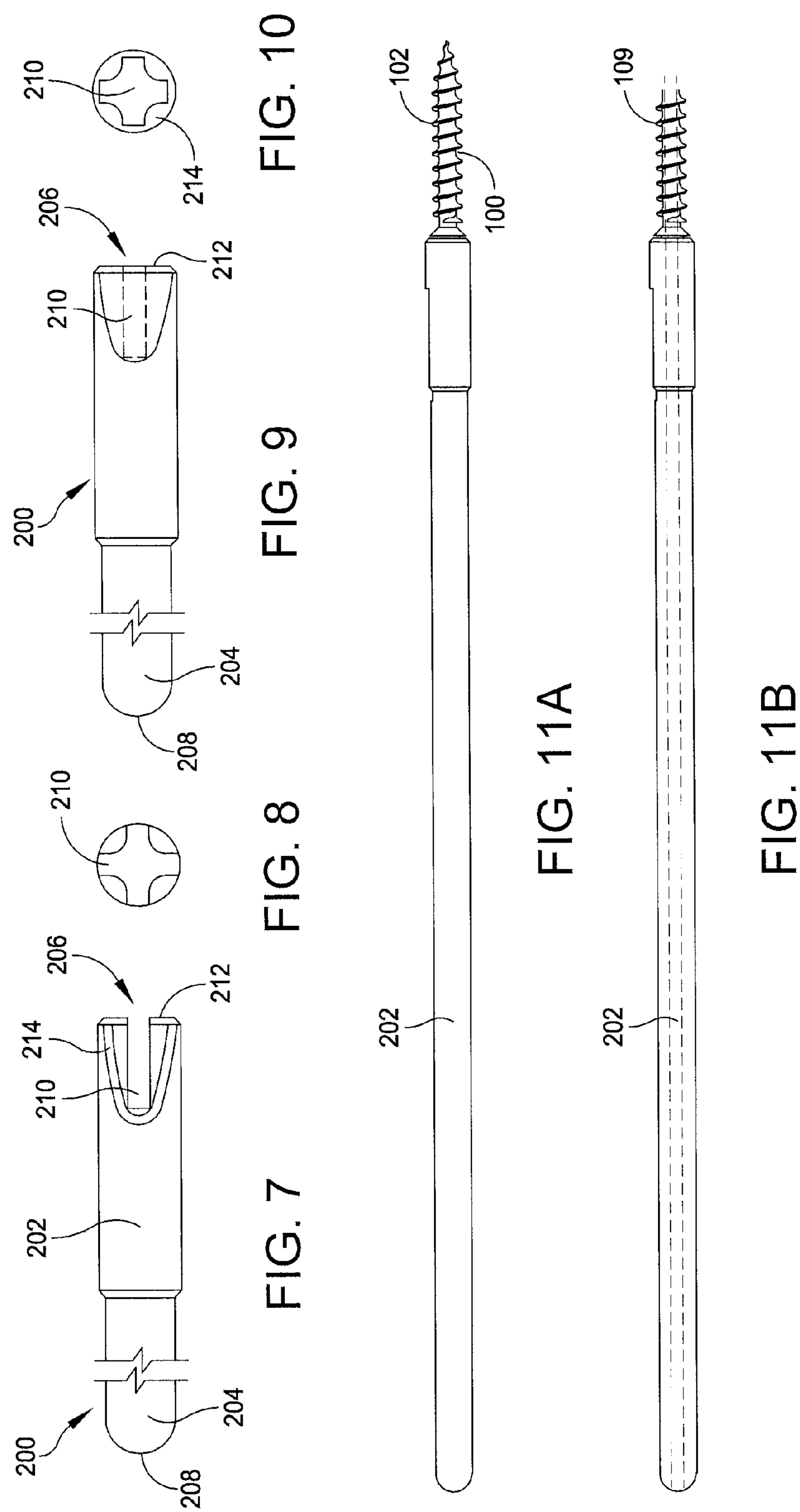

FIG. 7
FIG. 8
FIG. 9
FIG. 10
FIG. 11A
FIG. 11B

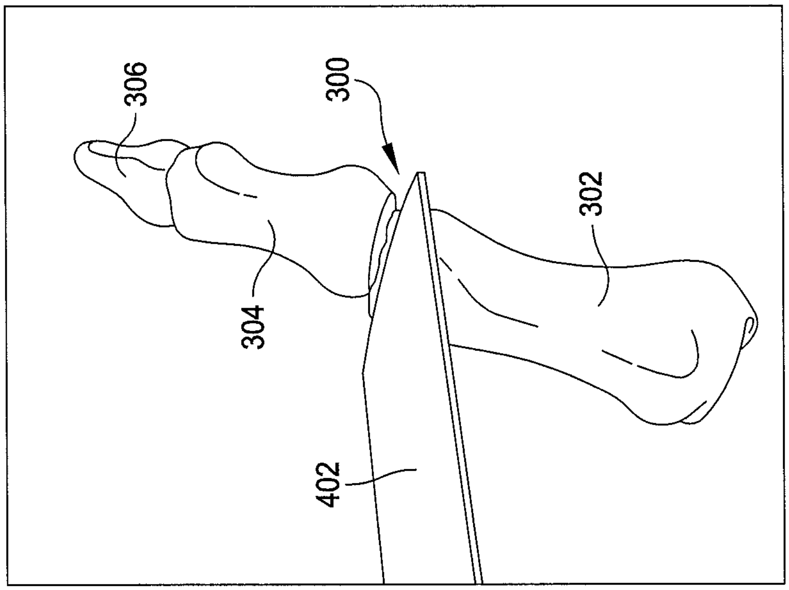

FIG. 12B

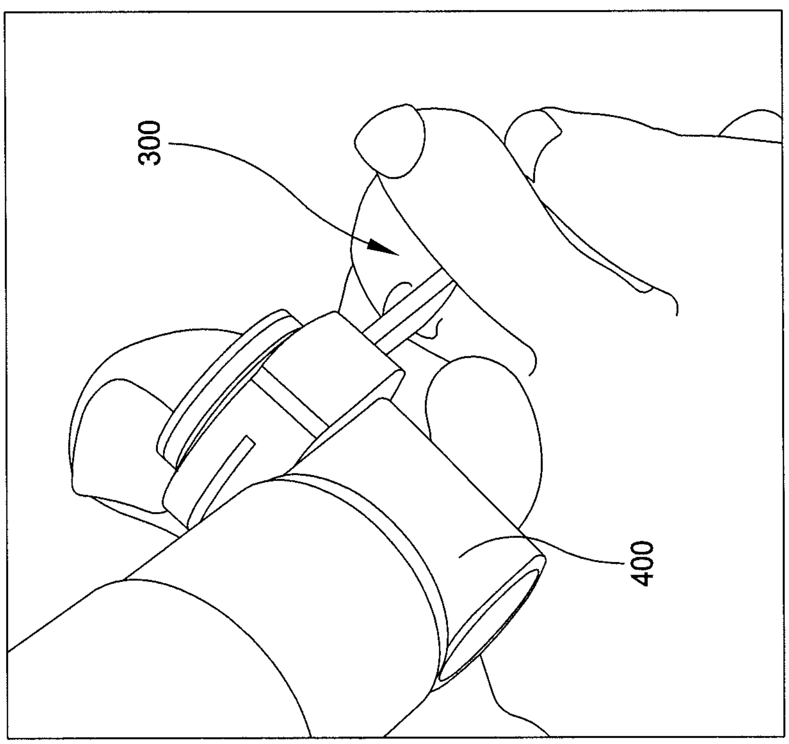

FIG. 12A

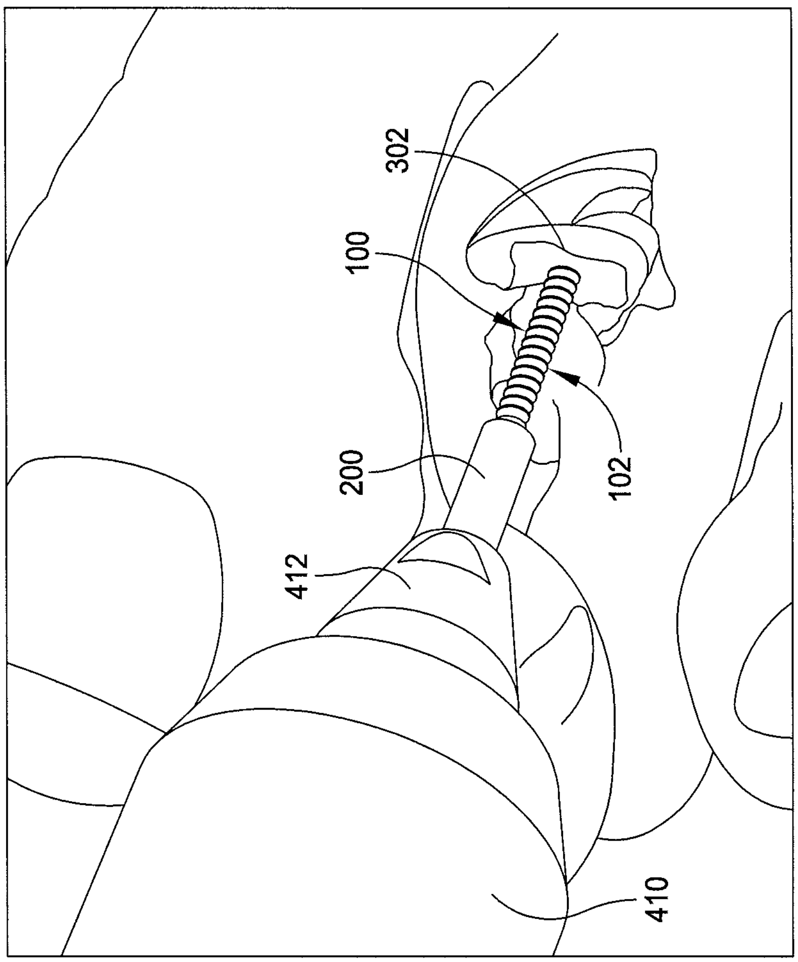

FIG. 13

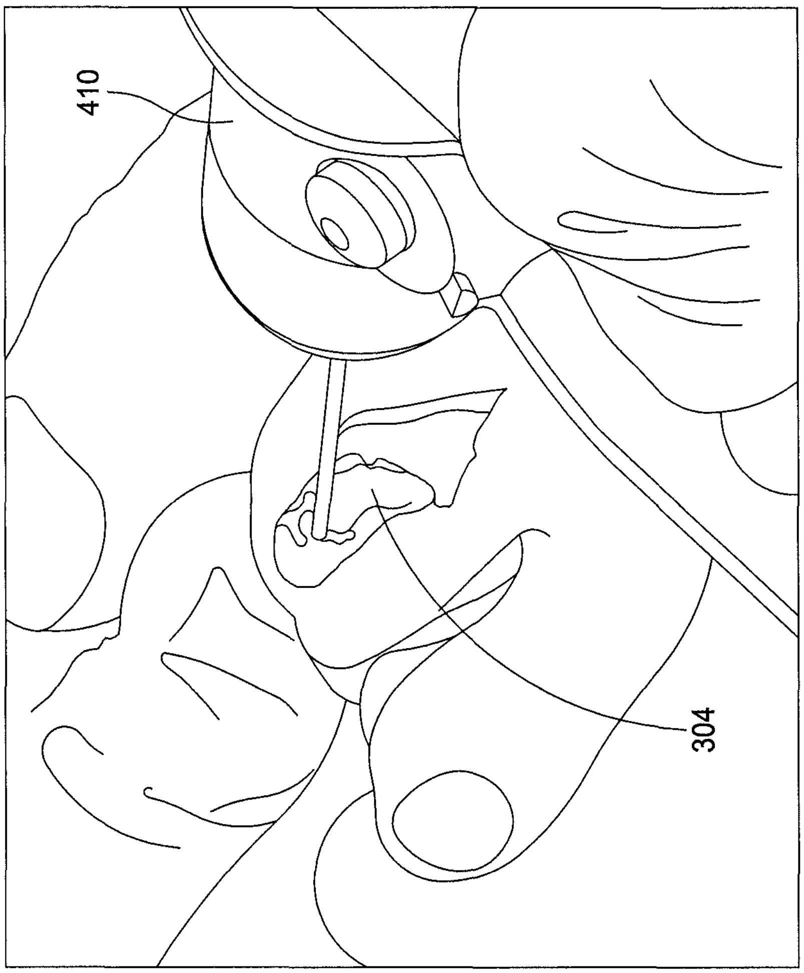

FIG. 14

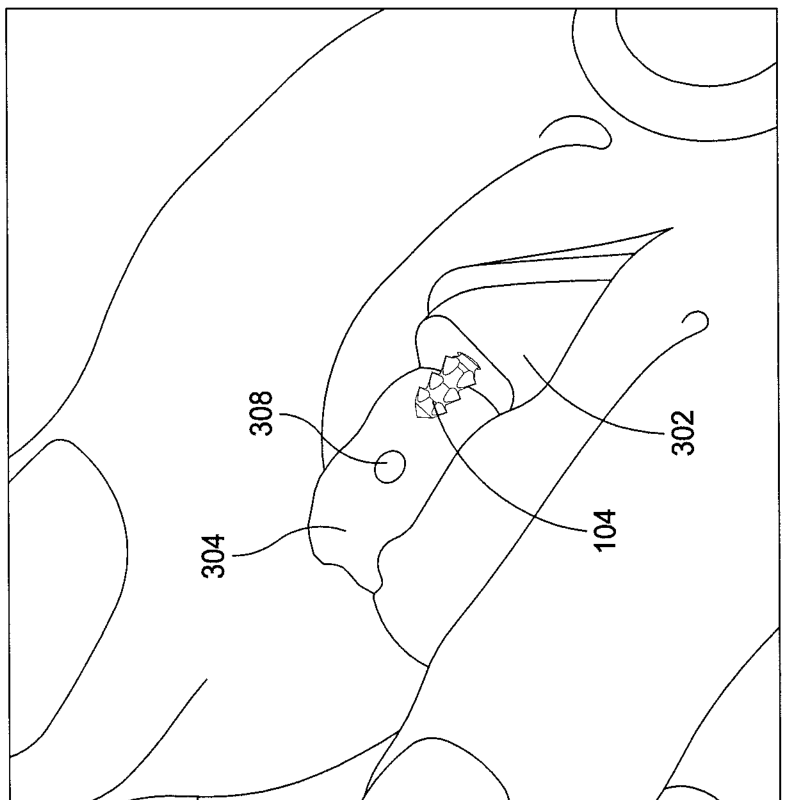

FIG. 15

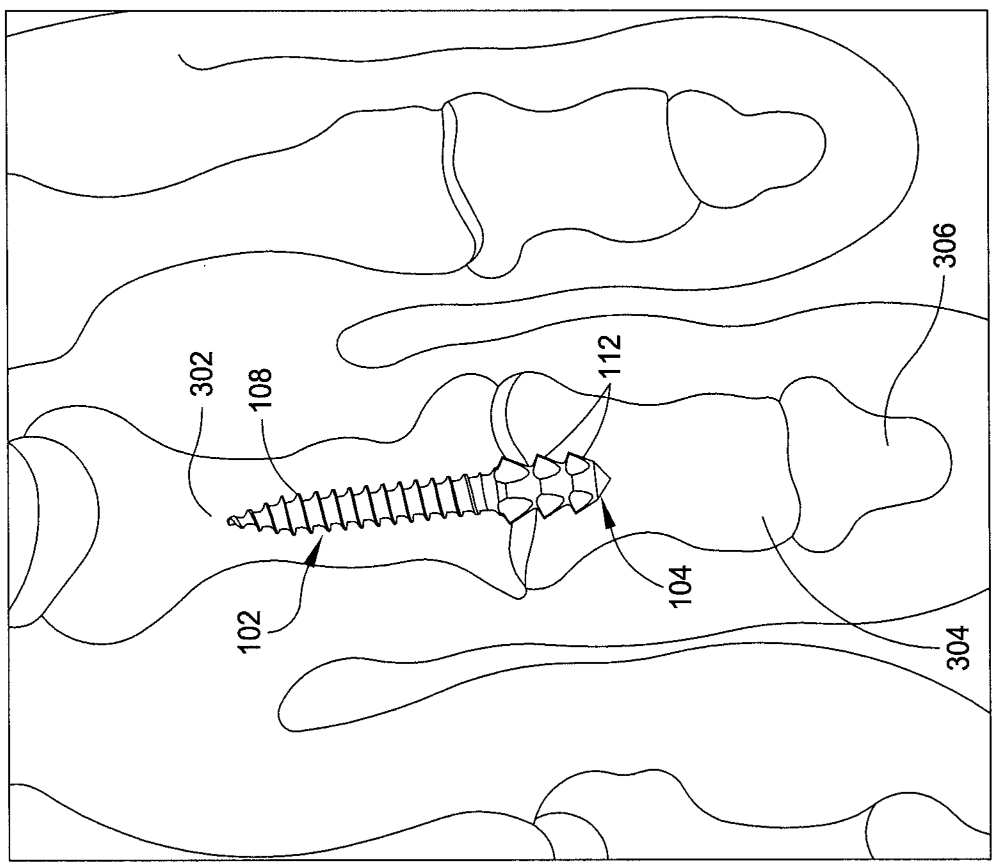

FIG. 16

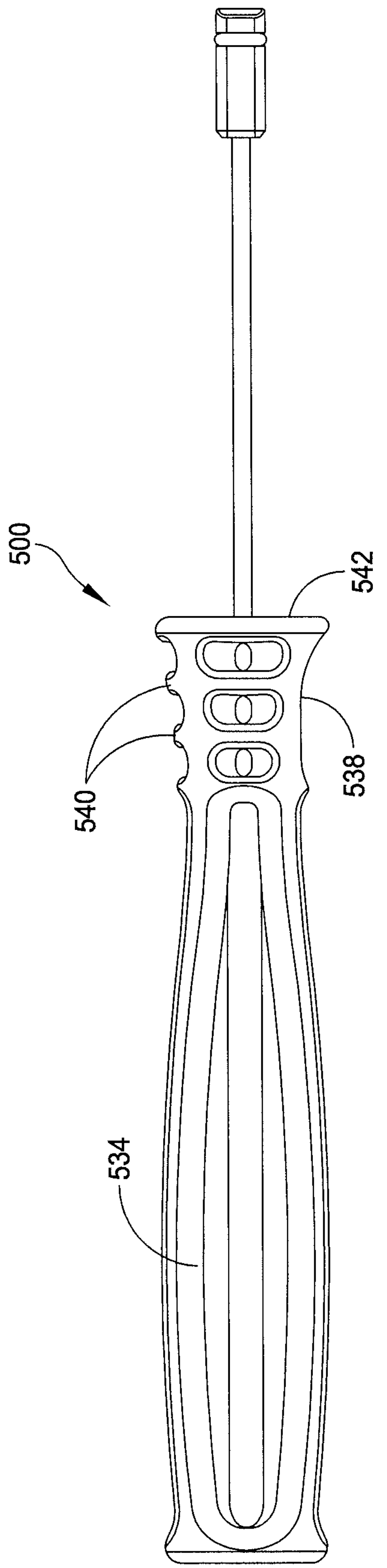

FIG. 17

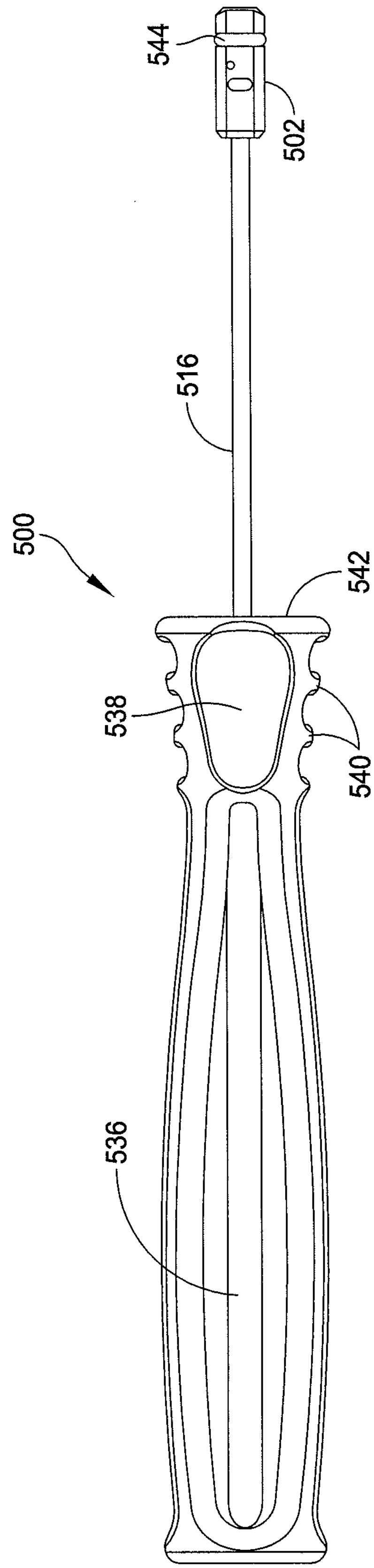

FIG. 18

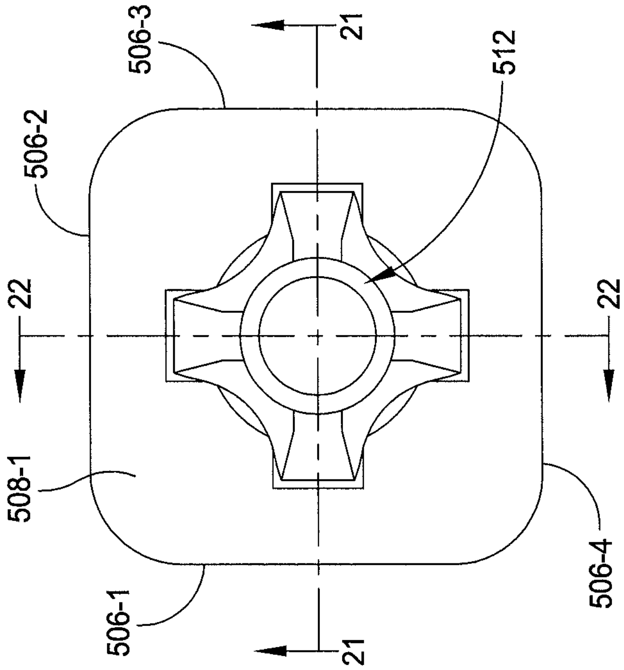

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FIG. 20

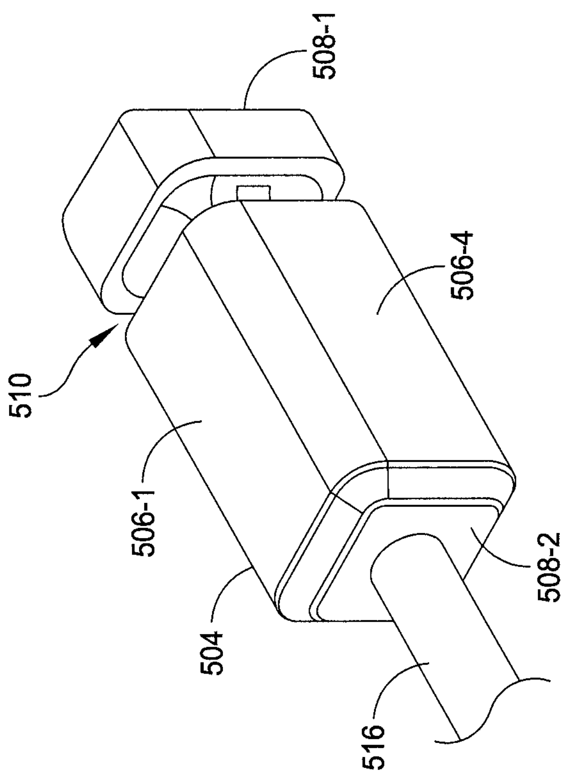

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FIG. 19

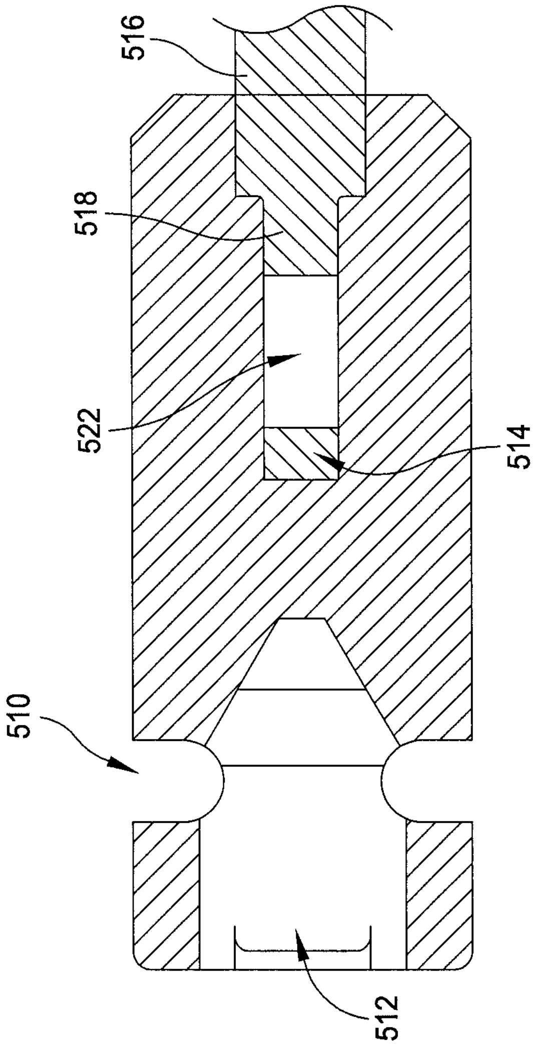


FIG. 22

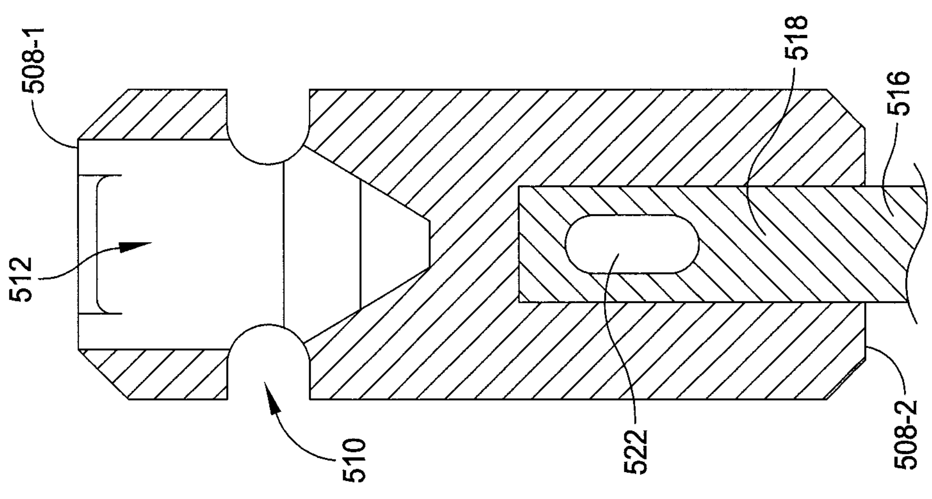


FIG. 21

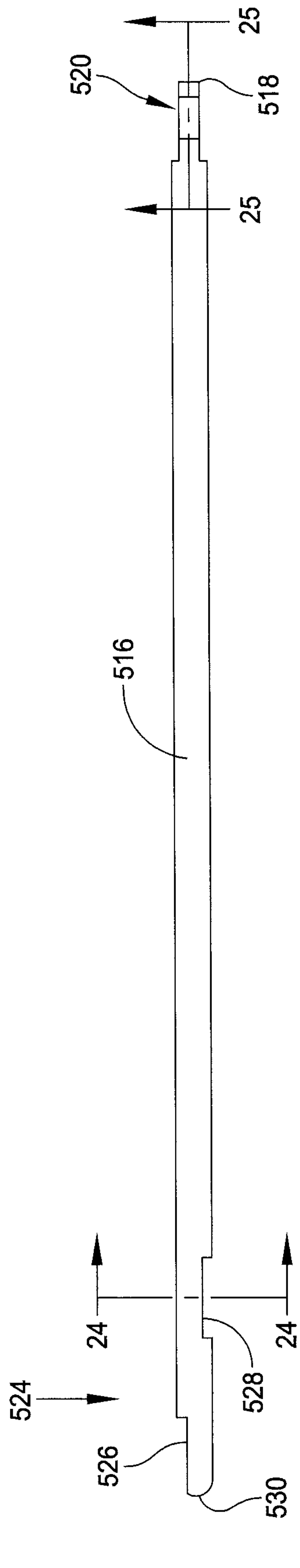


FIG. 23

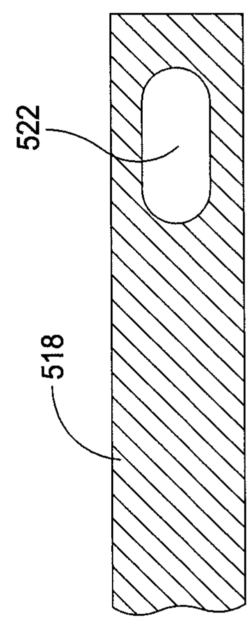


FIG. 25

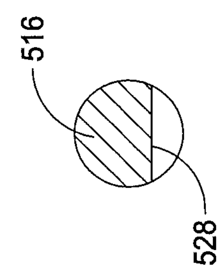


FIG. 24

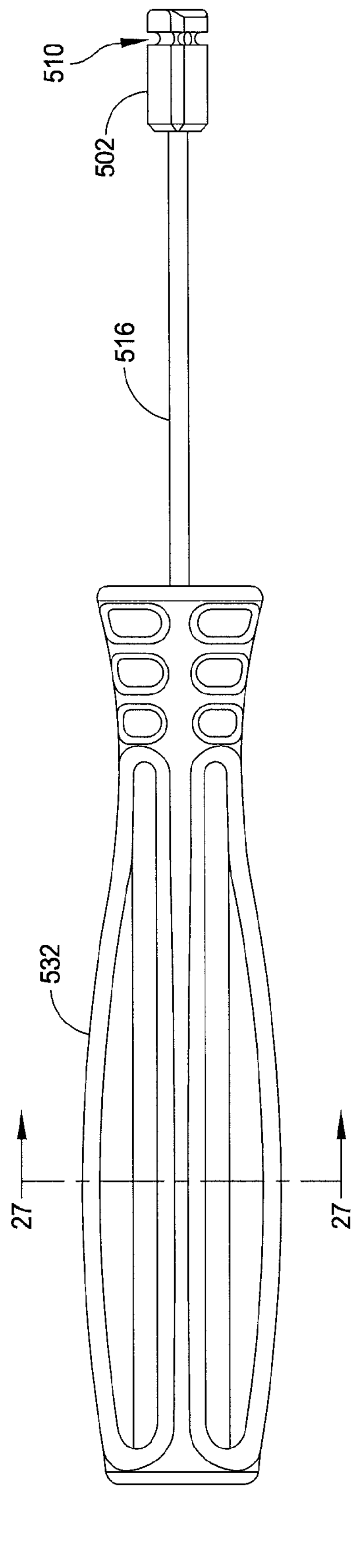


FIG. 26

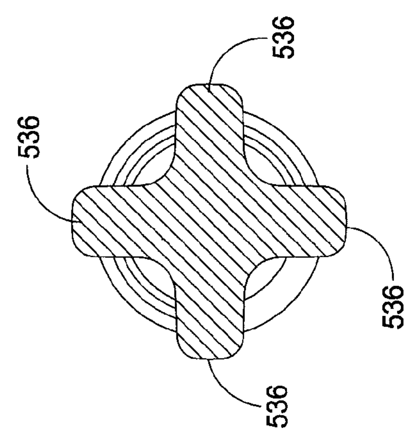


FIG. 27

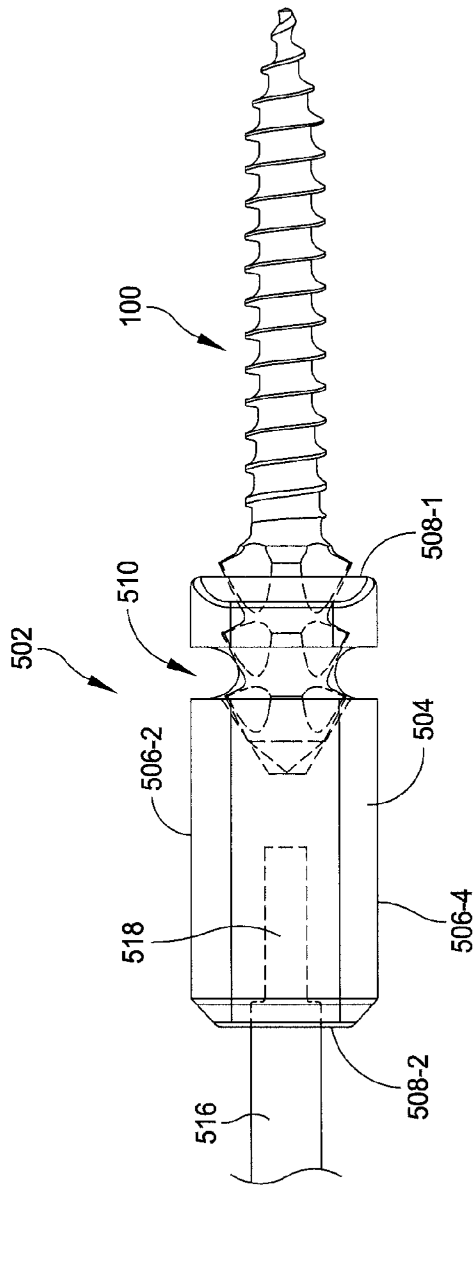


FIG. 28A

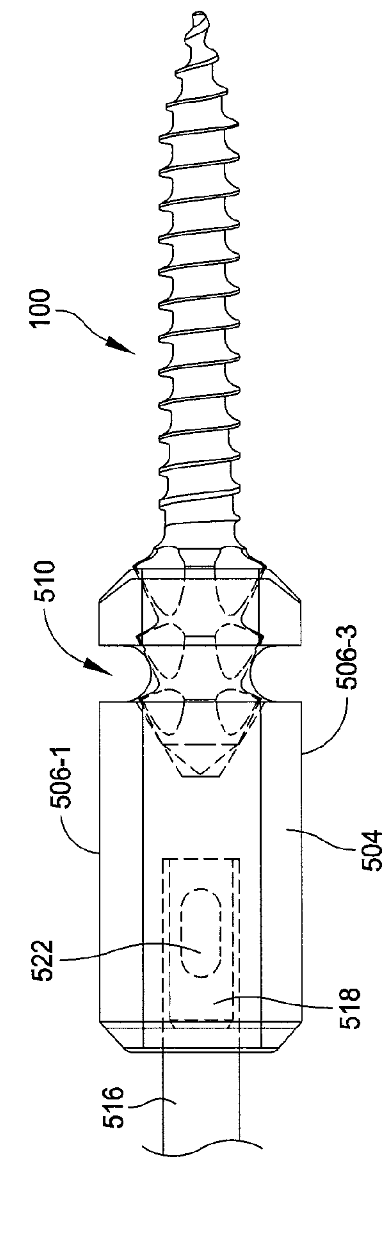


FIG. 28B

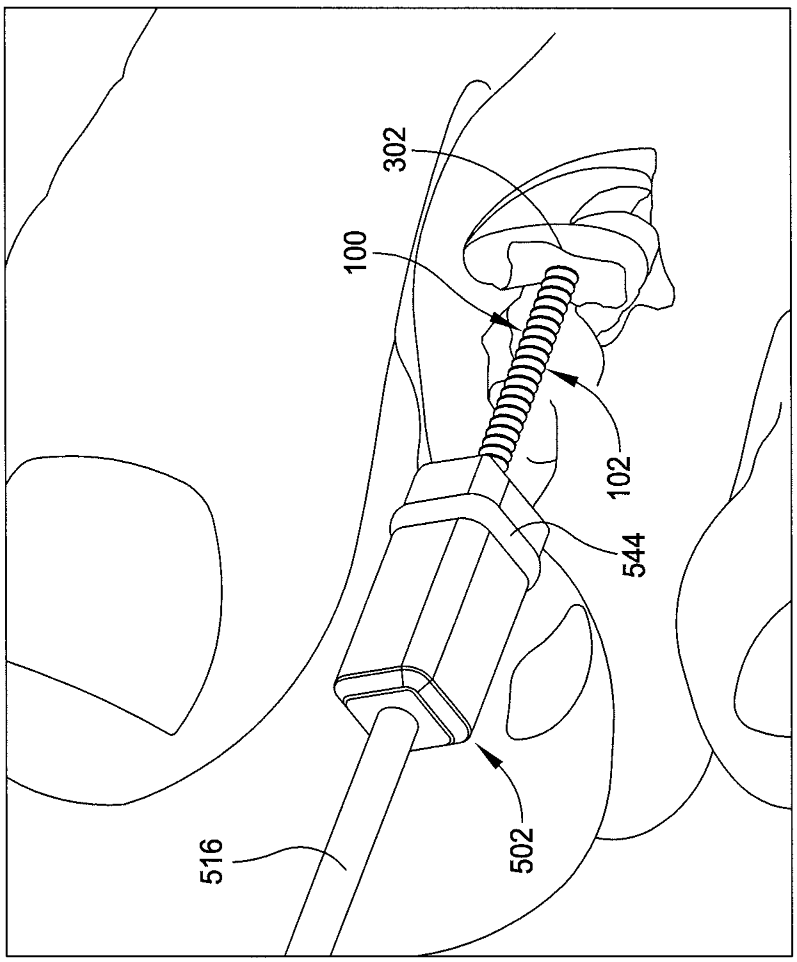


FIG. 29

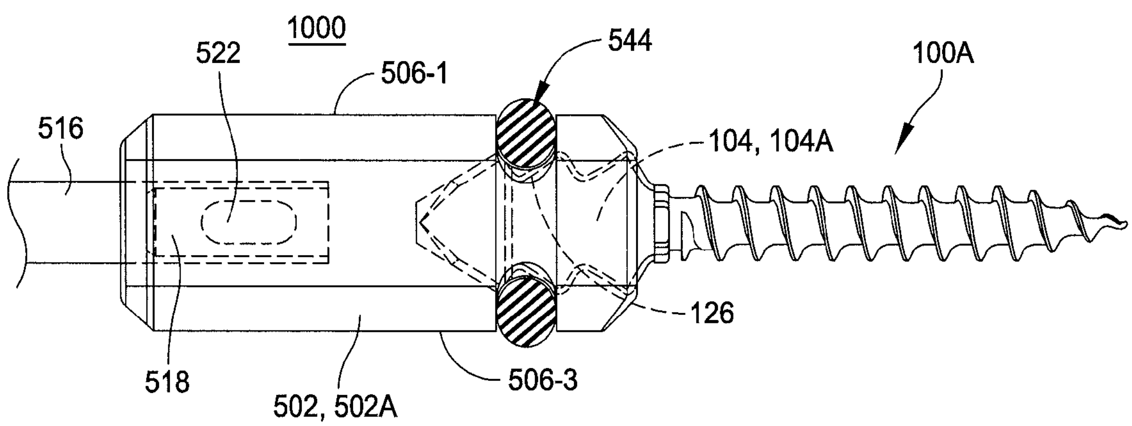


FIG. 30

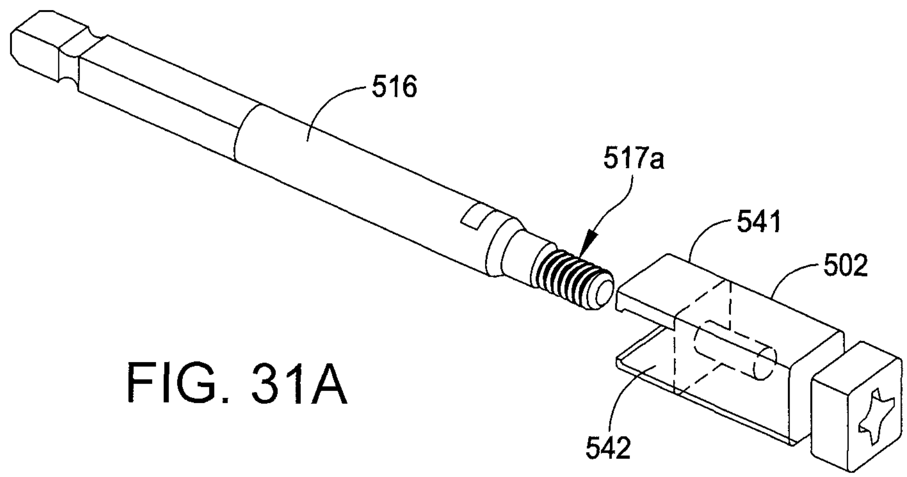


FIG. 31A

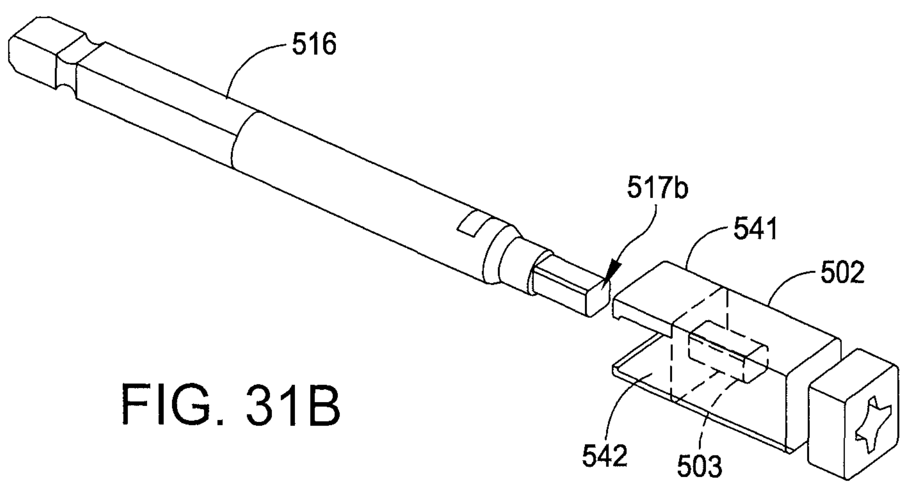


FIG. 31B

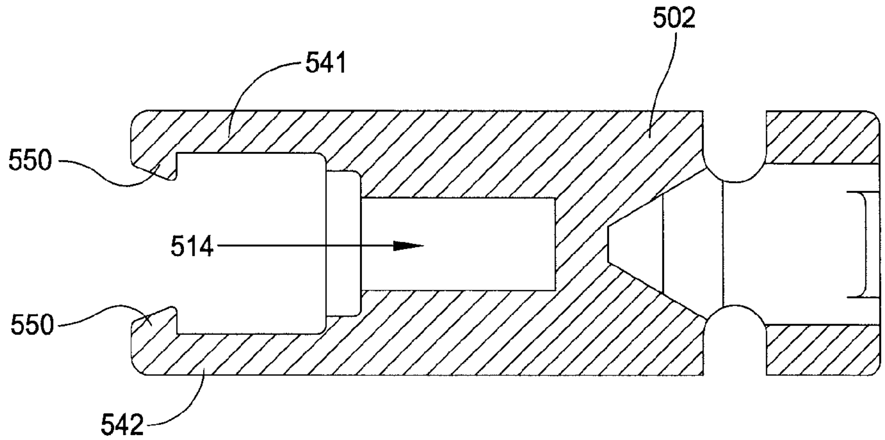


FIG. 31C

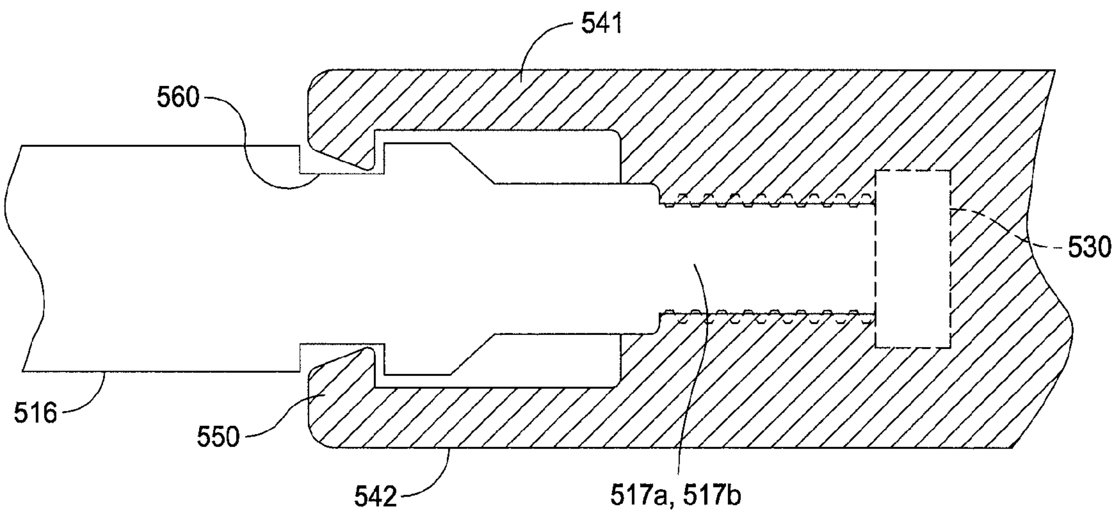


FIG. 31D

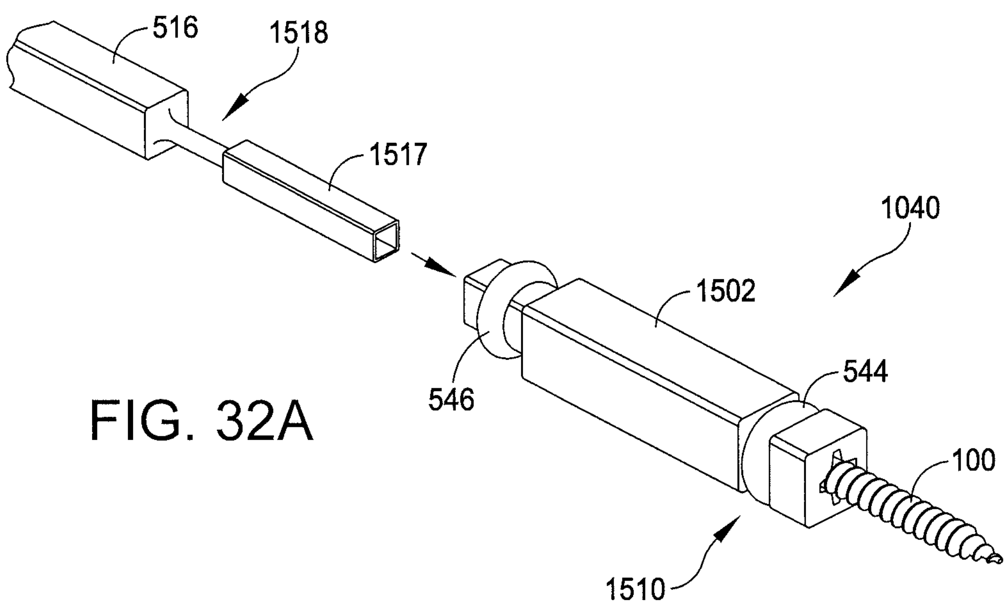


FIG. 32A

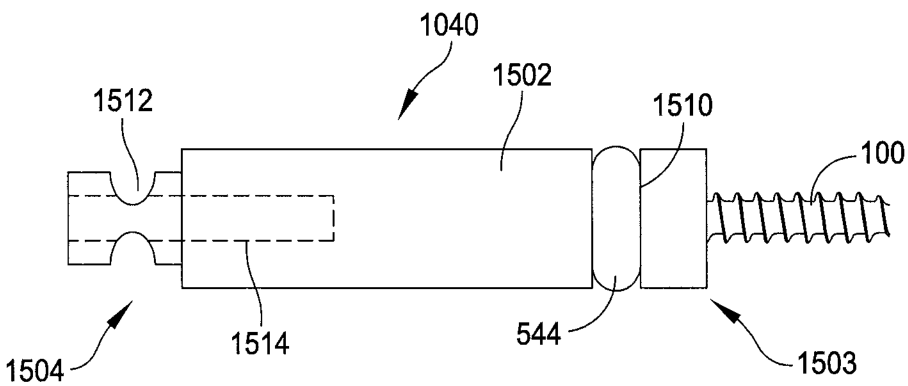


FIG. 32B

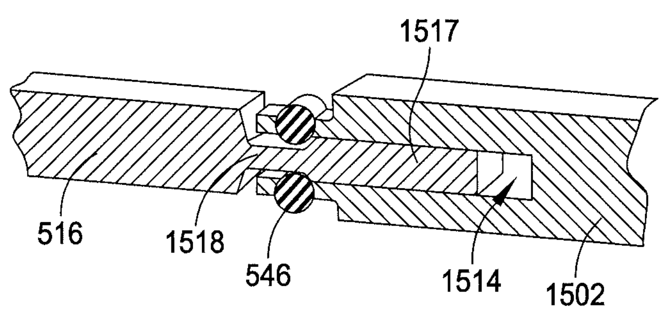


FIG. 32C

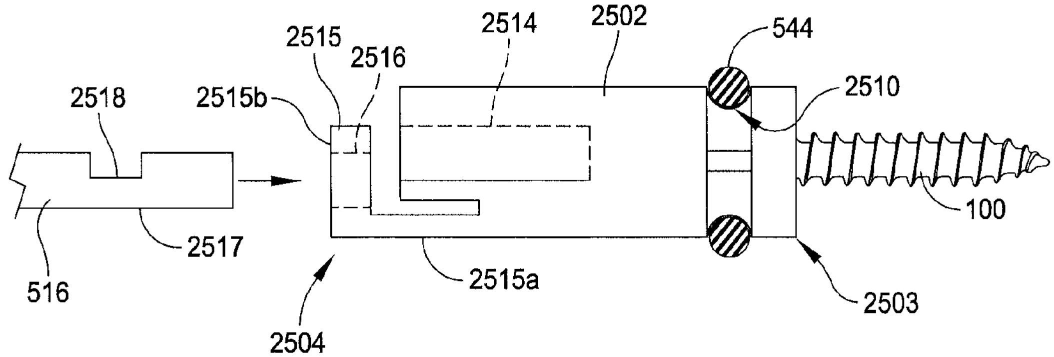


FIG. 33A

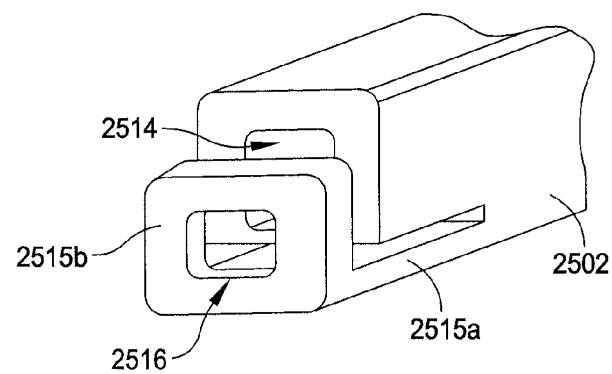


FIG. 33B

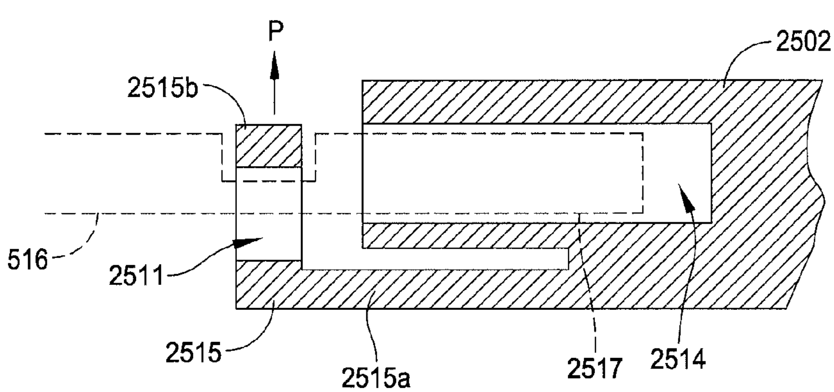
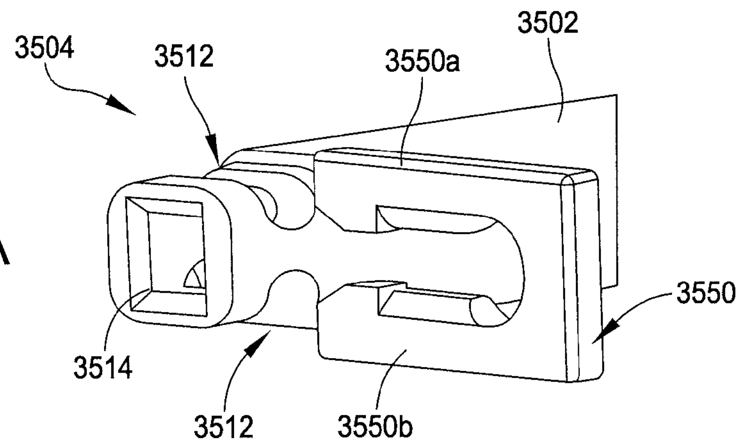


FIG. 33C

FIG. 34A



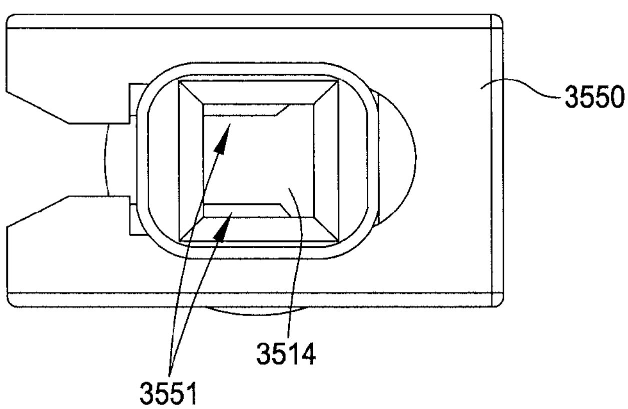
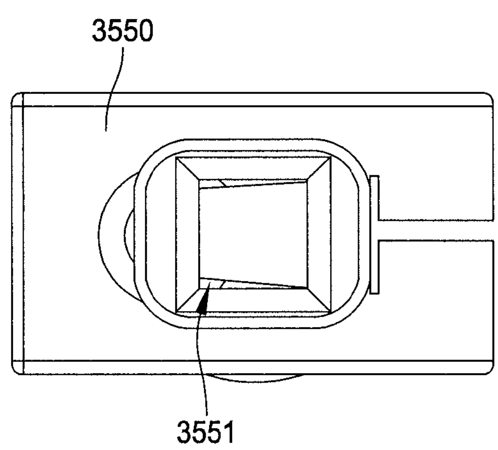


FIG. 34B

FIG. 34C



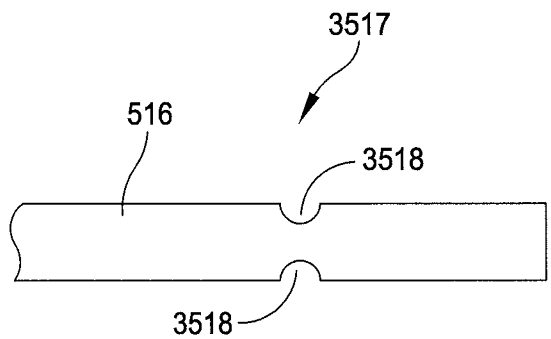


FIG. 34E

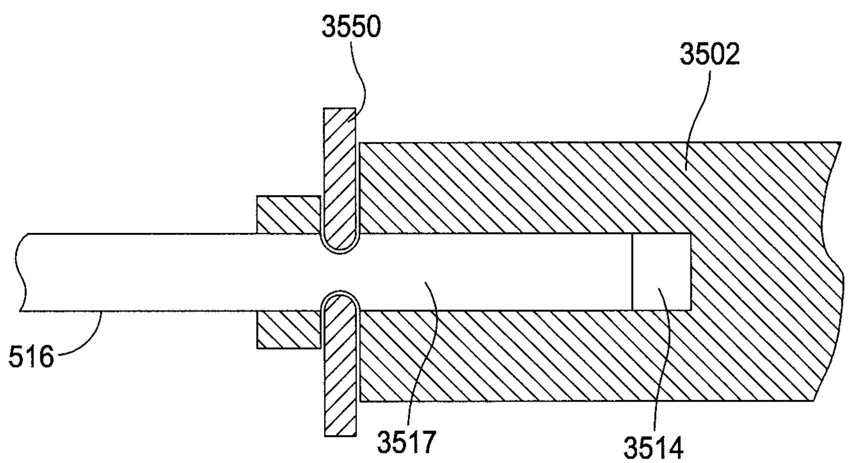


FIG. 34D

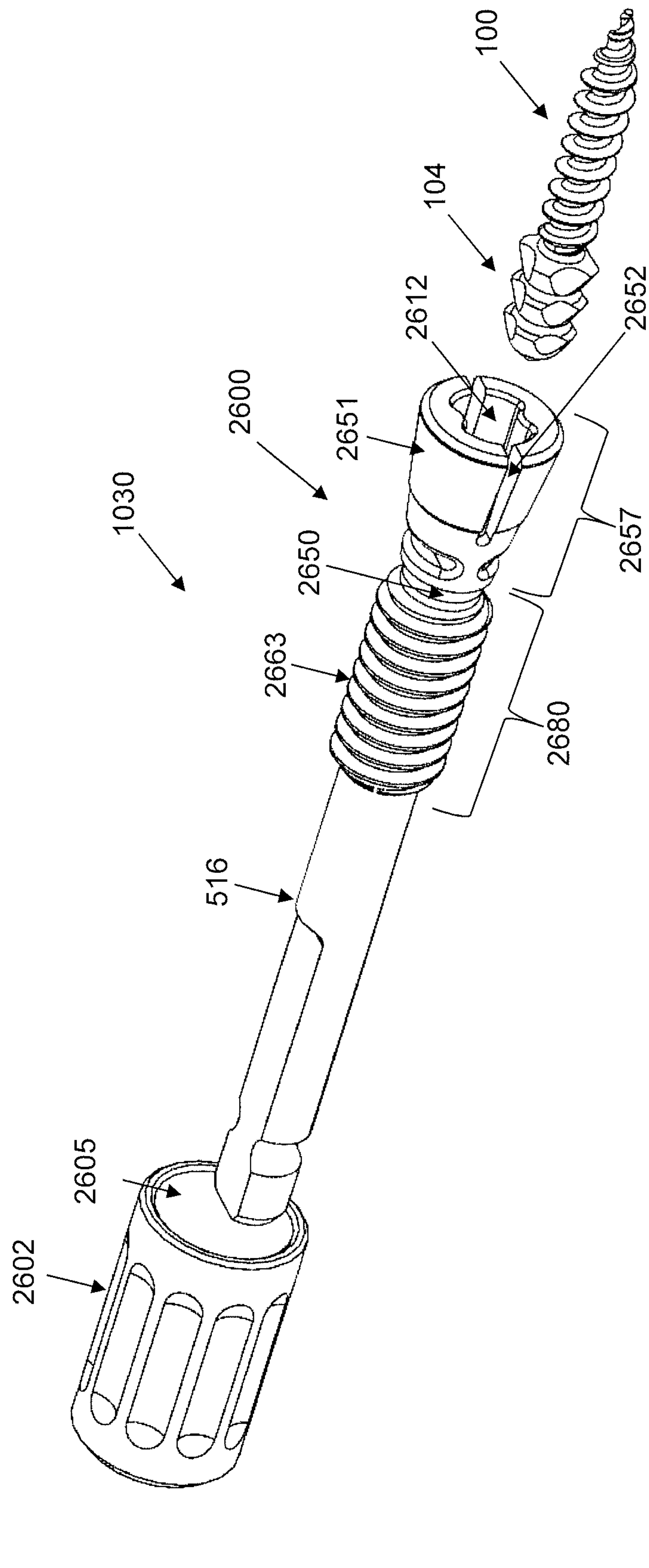

100
104
2612
2652
2600
2651
1030
2657
2650
2663
2680
516
2605
2602

FIG. 35A

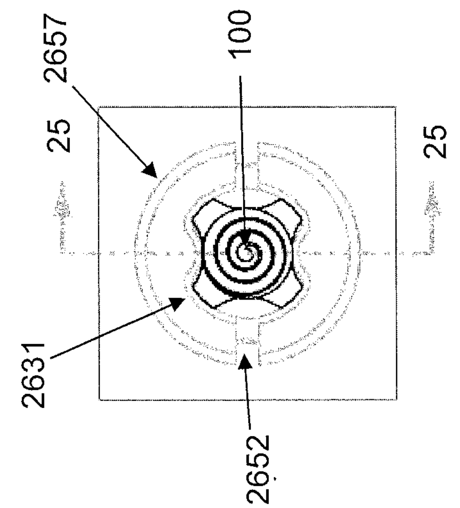


FIG. 35D

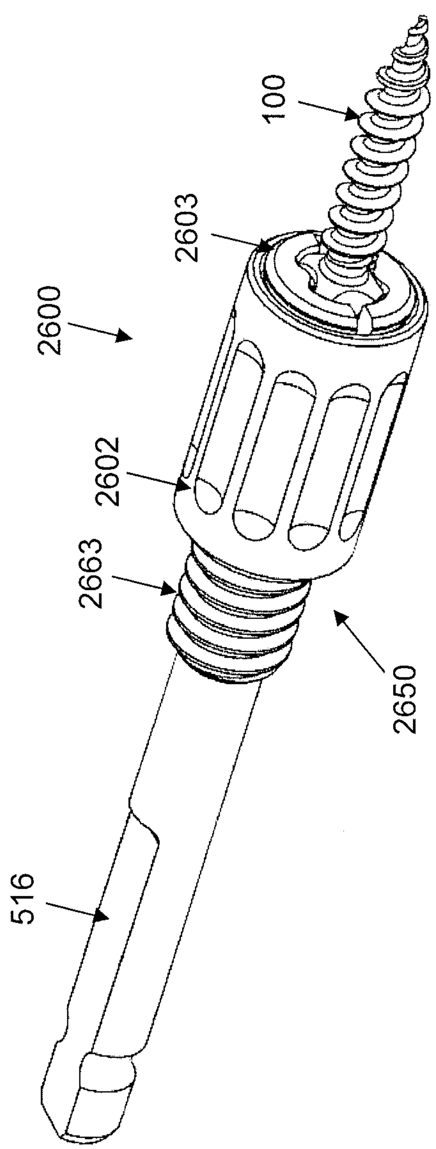


FIG. 35B

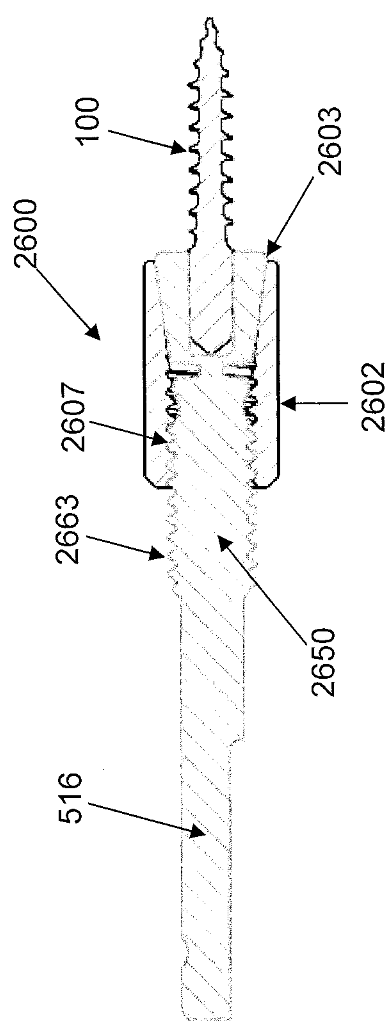


FIG. 35E

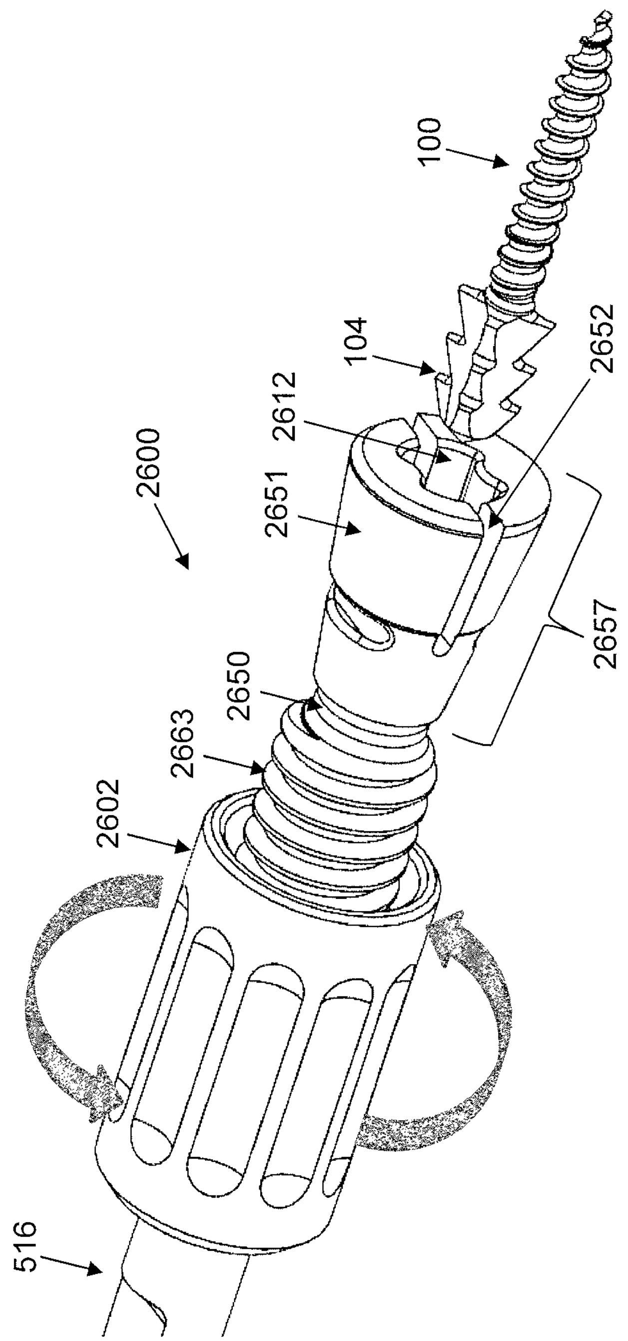


FIG. 35C

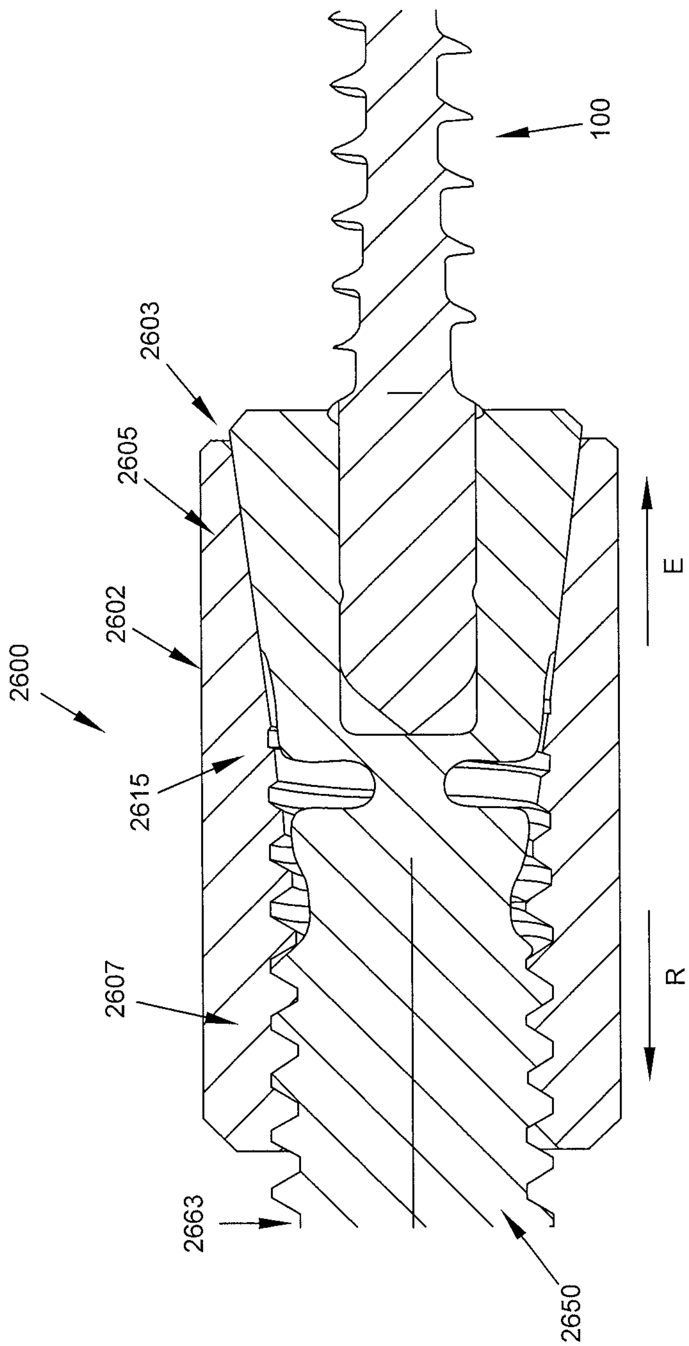


FIG. 35F

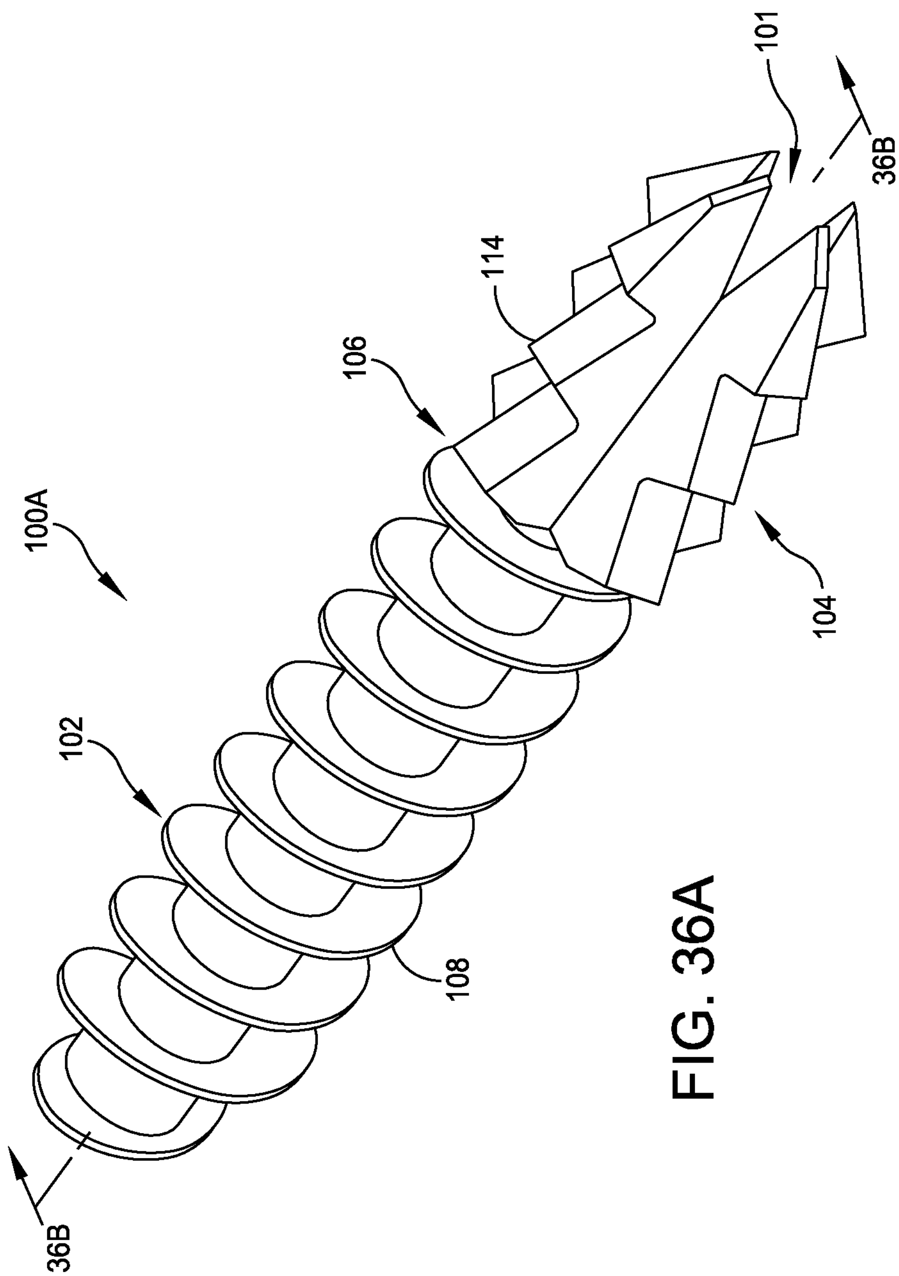


FIG. 36A

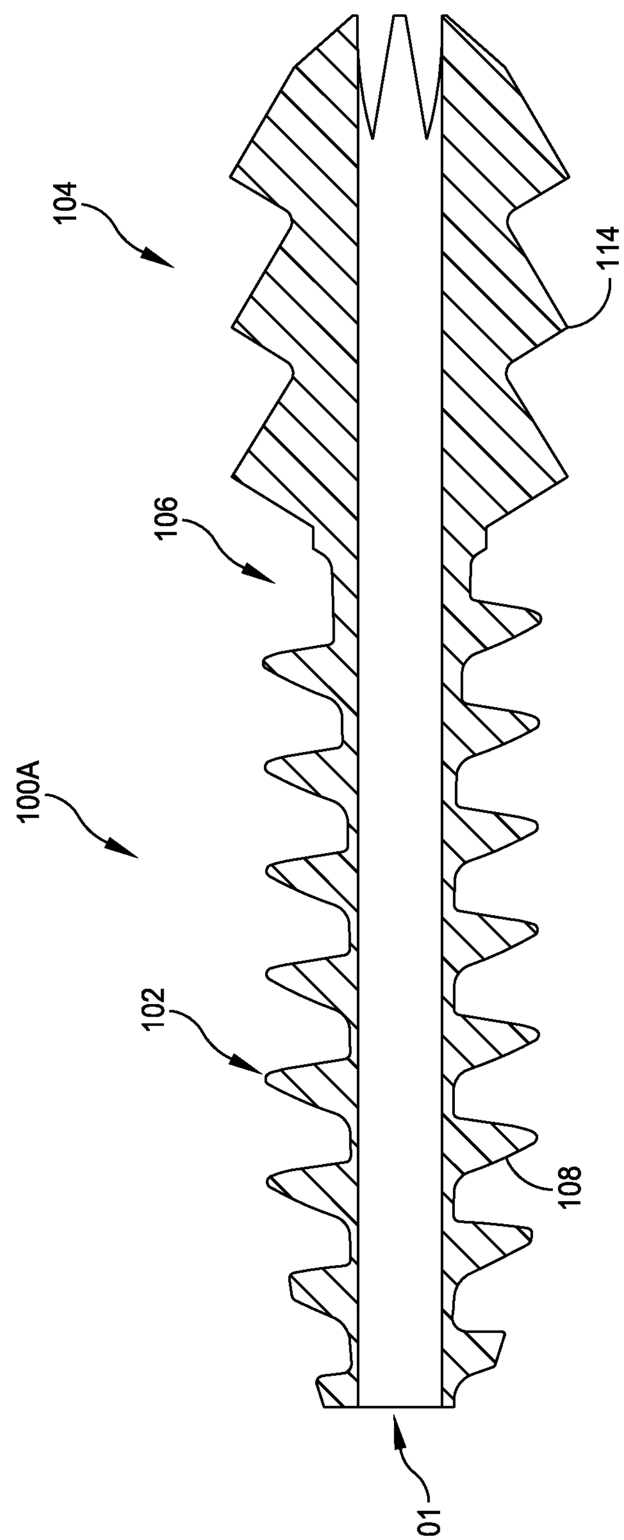


FIG. 36B

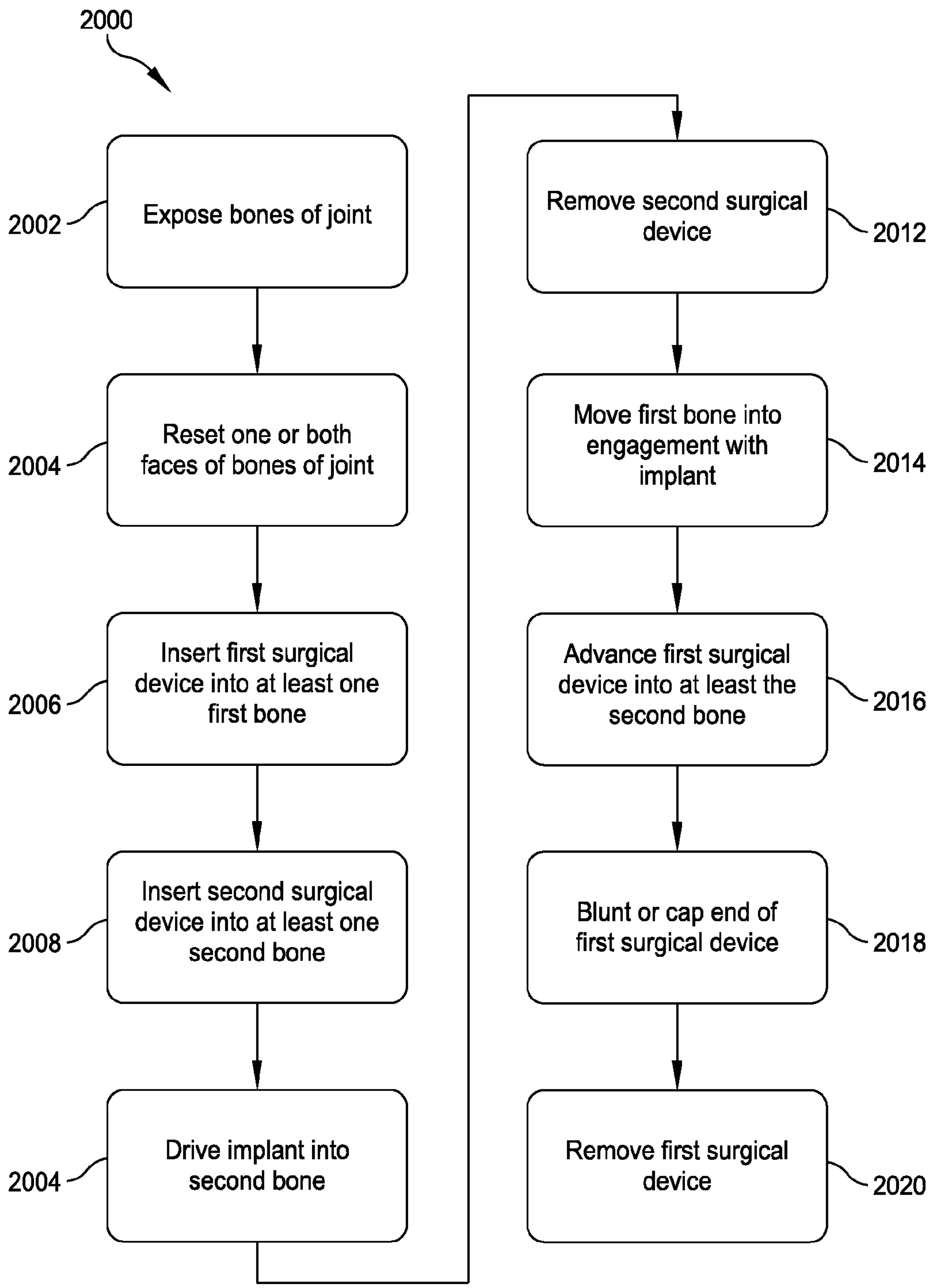

2000
2002
Expose bones of joint
2004
Reset one or both faces of bones of joint
2006
Insert first surgical device into at least one first bone
2008
Insert second surgical device into at least one second bone
2004
Drive implant into second bone
Remove second surgical device
2012
Move first bone into engagement with implant
2014
Advance first surgical device into at least the second bone
2016
Blunt or cap end of first surgical device
2018
Remove first surgical device
2020

FIG. 37

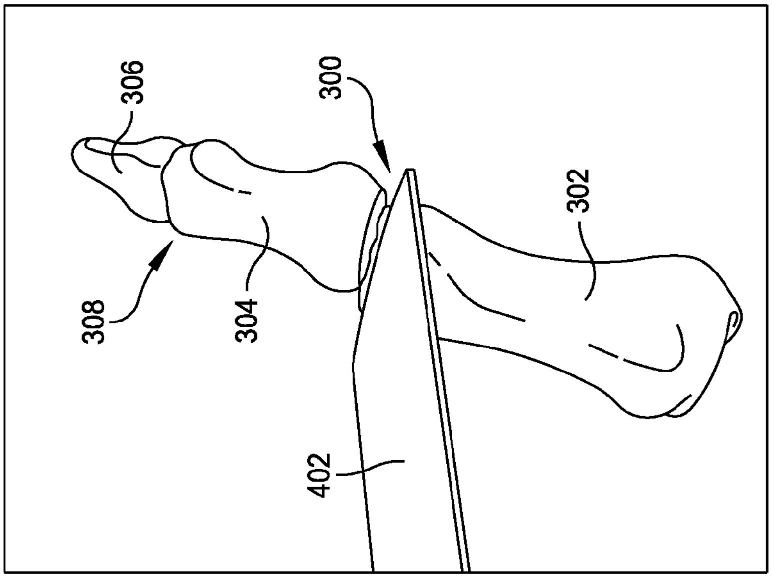


FIG. 39

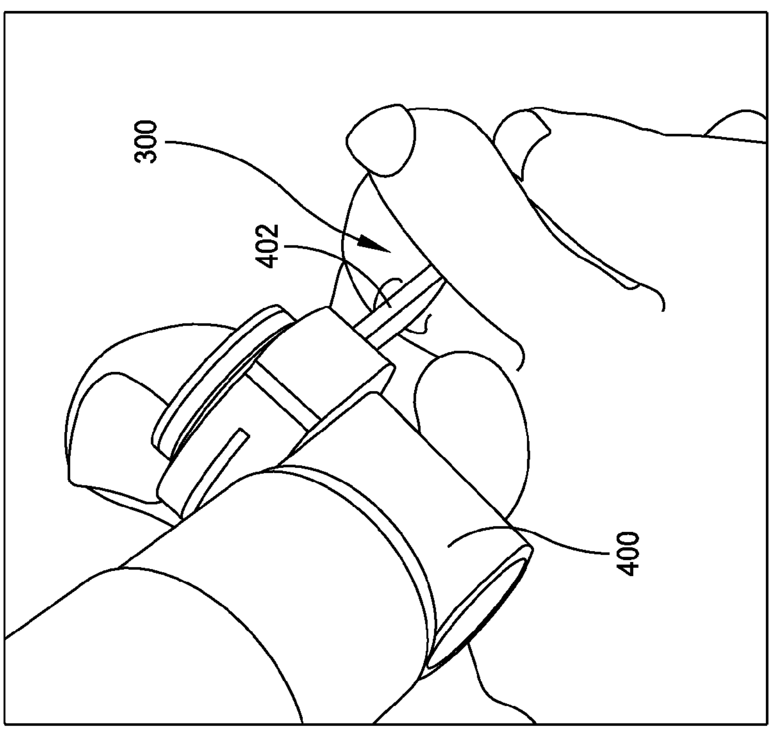


FIG. 38

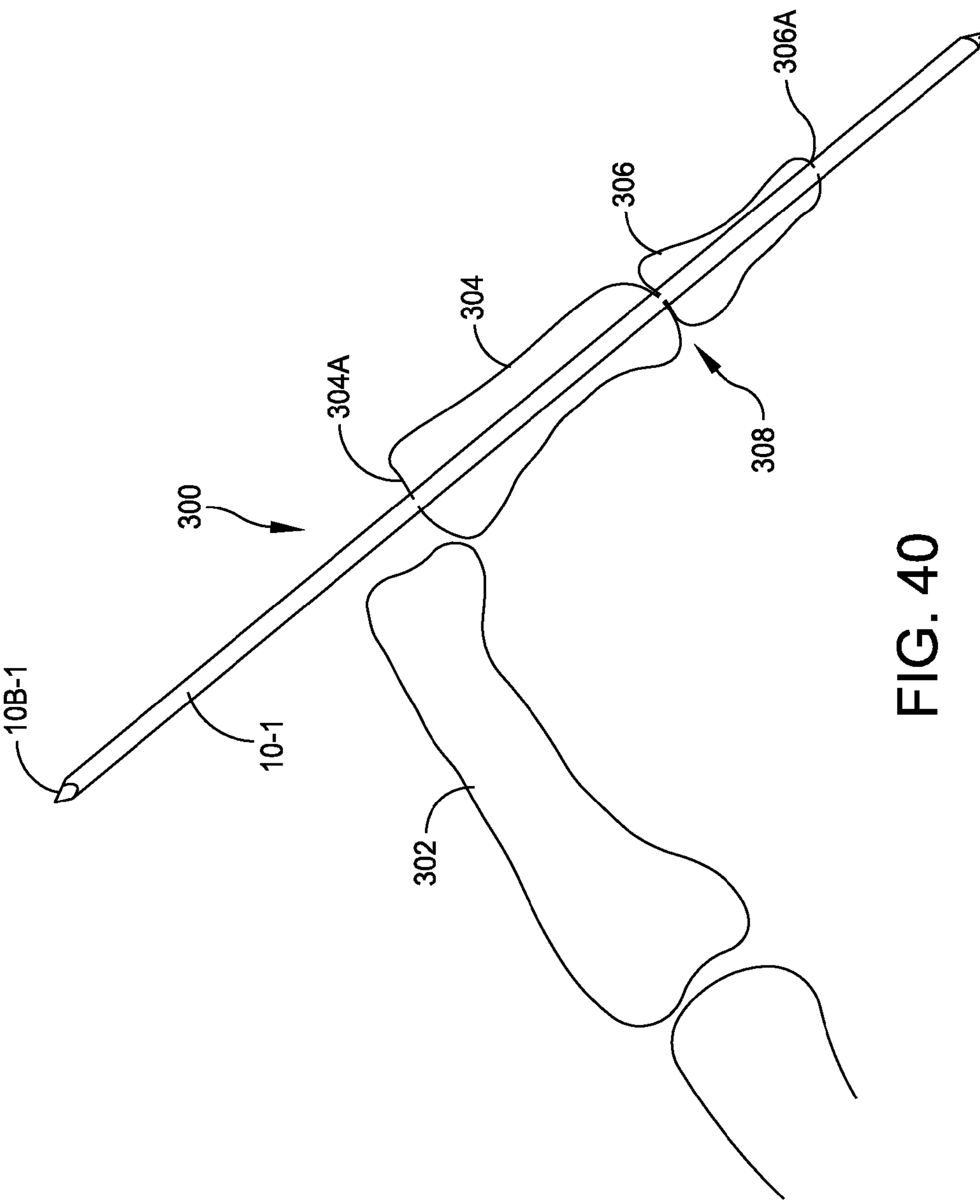


FIG. 40

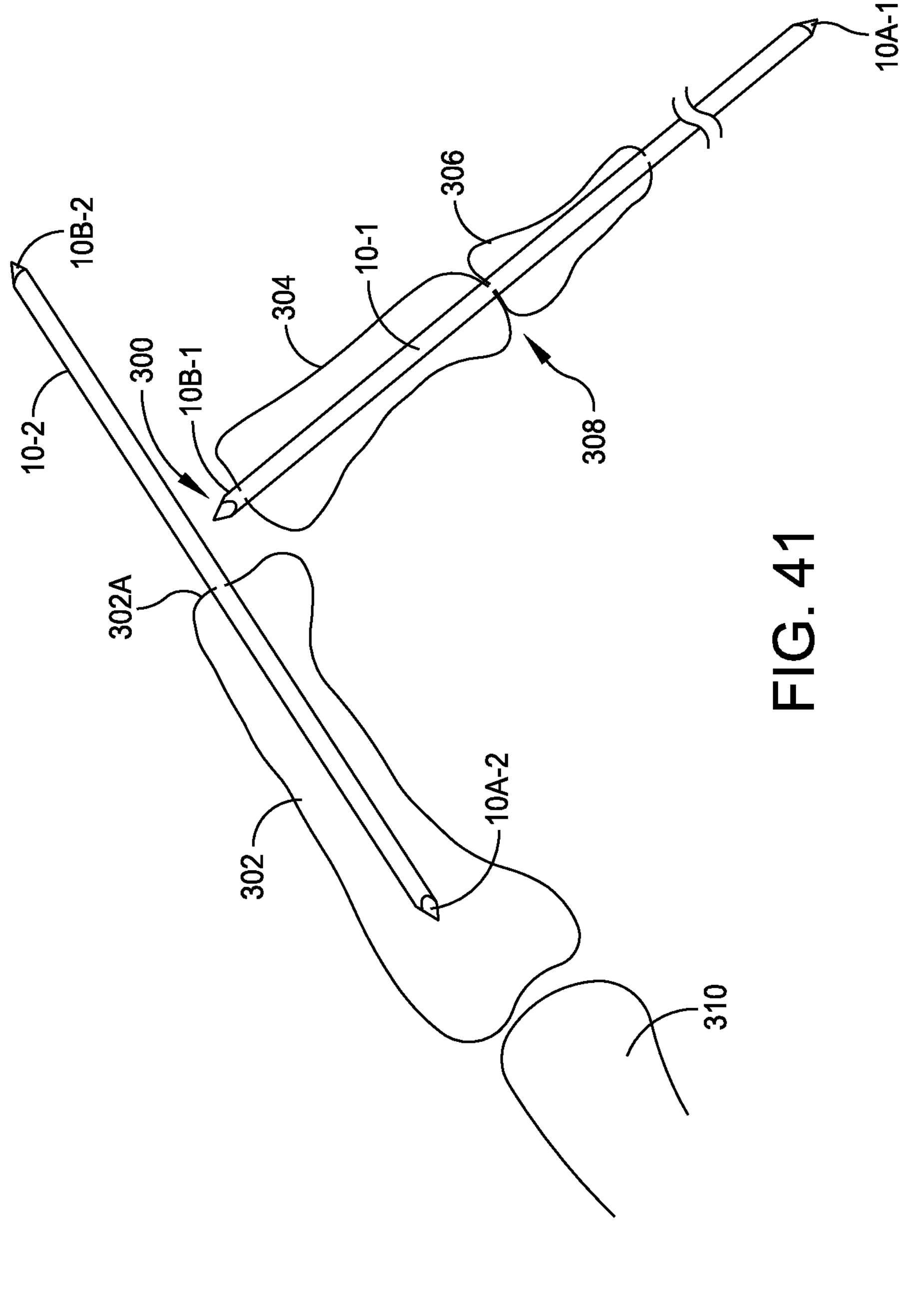


FIG. 41

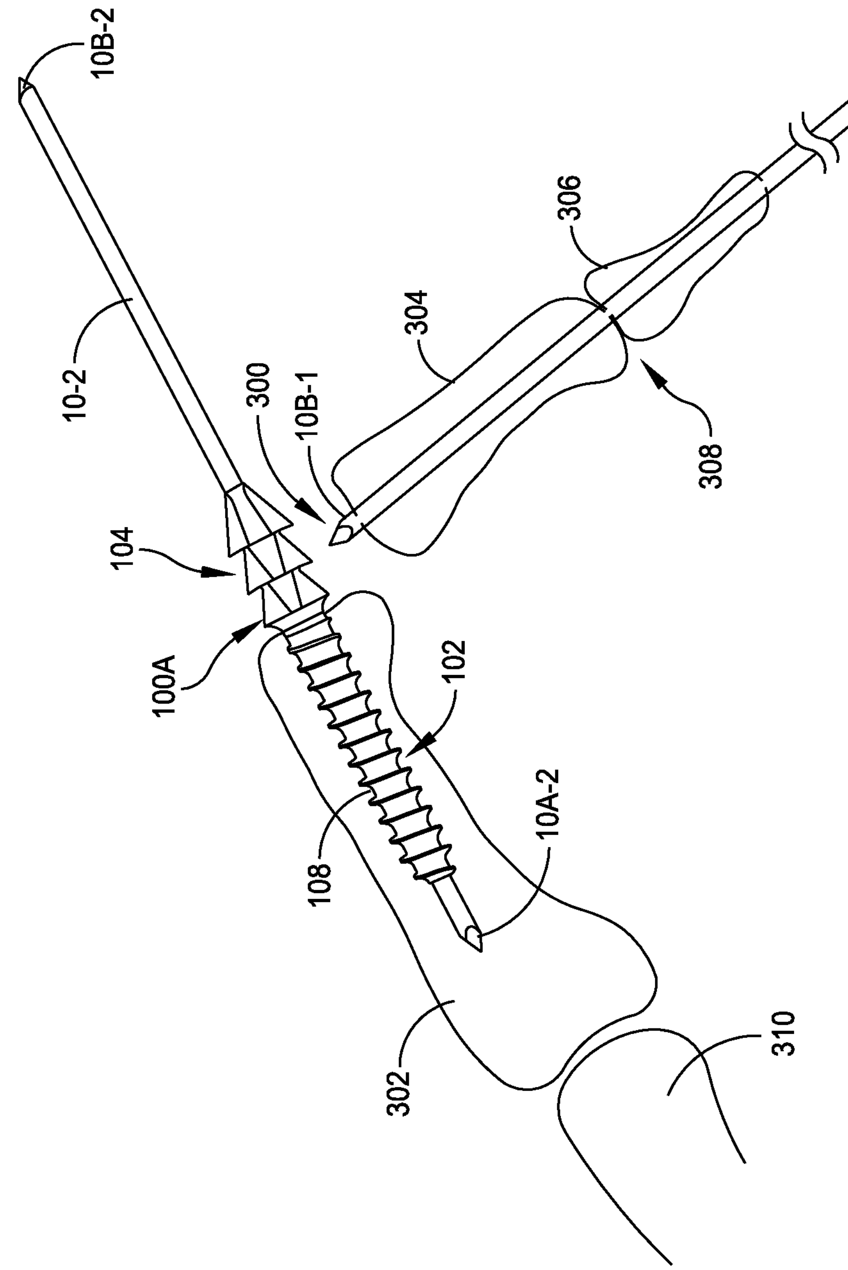

10B-2
10A-1
306
304
10-2
300
10B-1
308
104
100A
102
108
10A-2
302
310

FIG. 42A

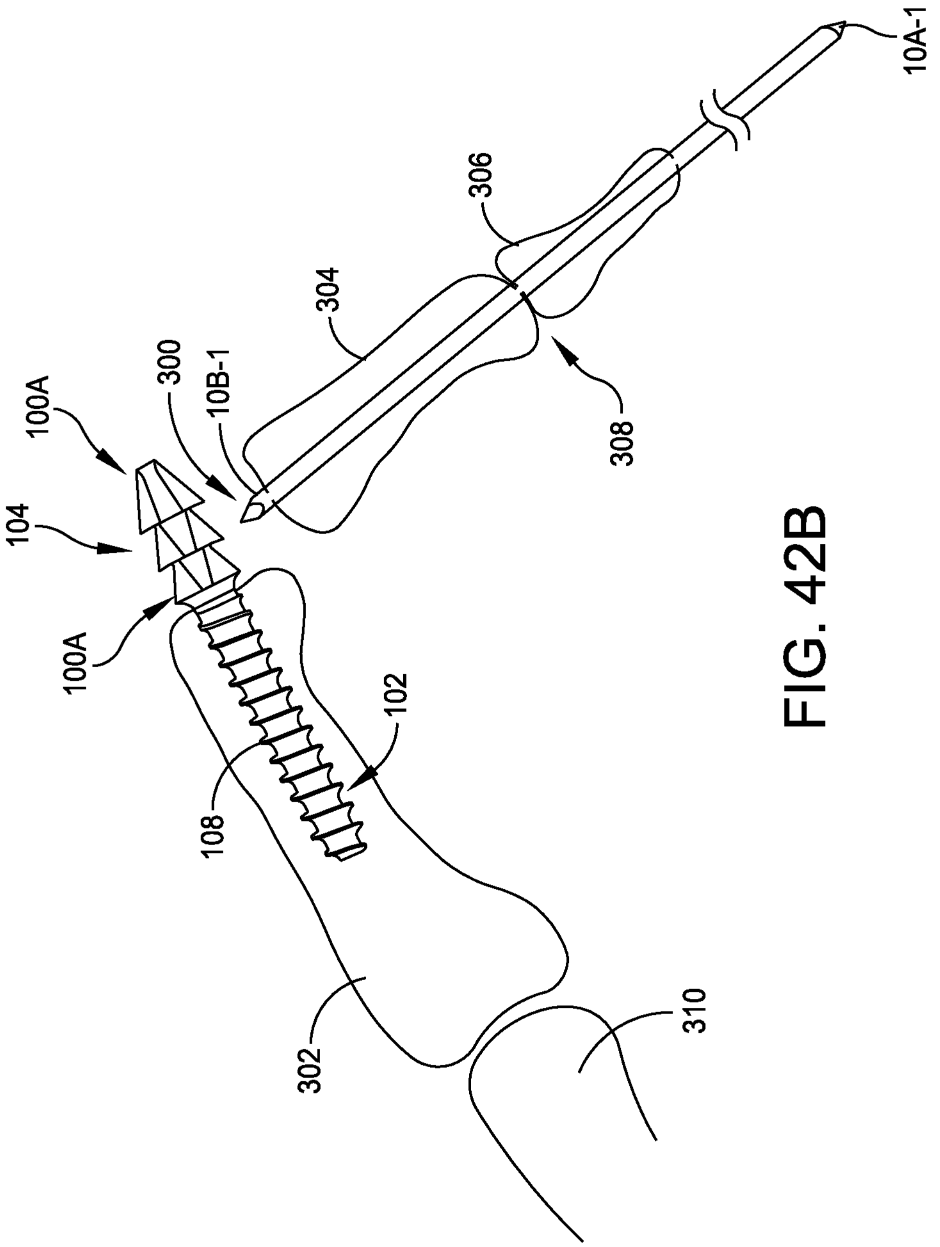


FIG. 42B

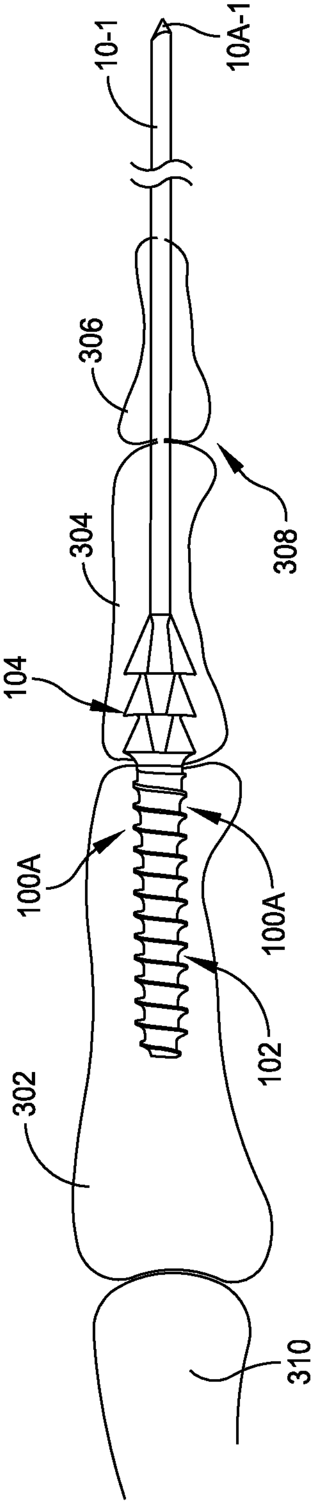

10-1
10A-1
306
308
304
104
100A
100A
102
302
310

FIG. 43

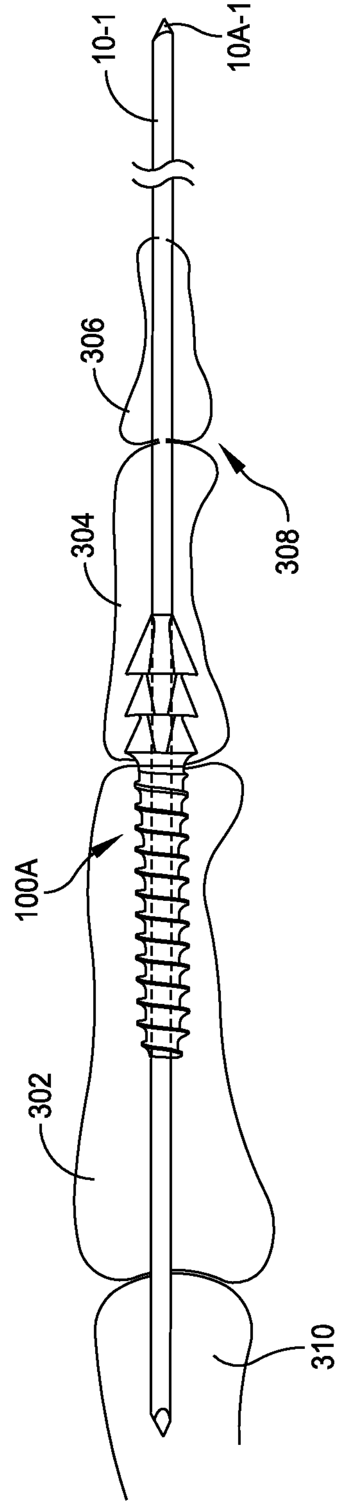

10-1
10A-1
306
308
304
100A
302
310

FIG. 44

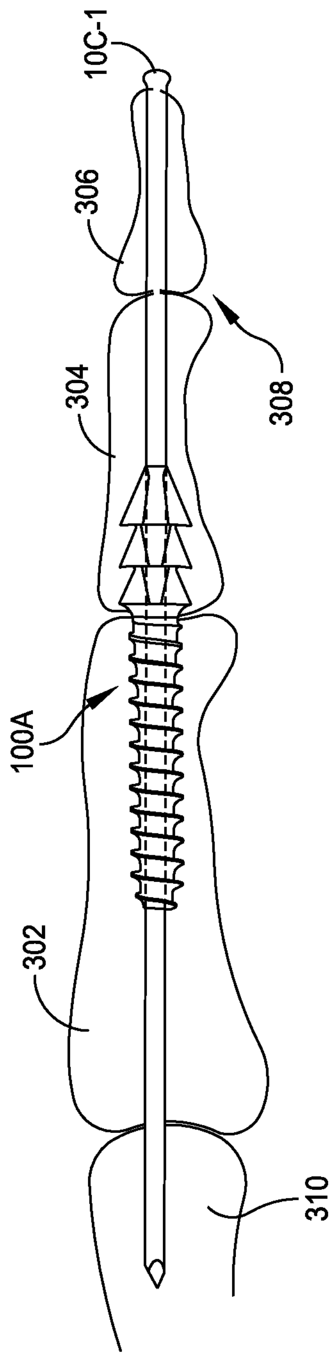


FIG. 45

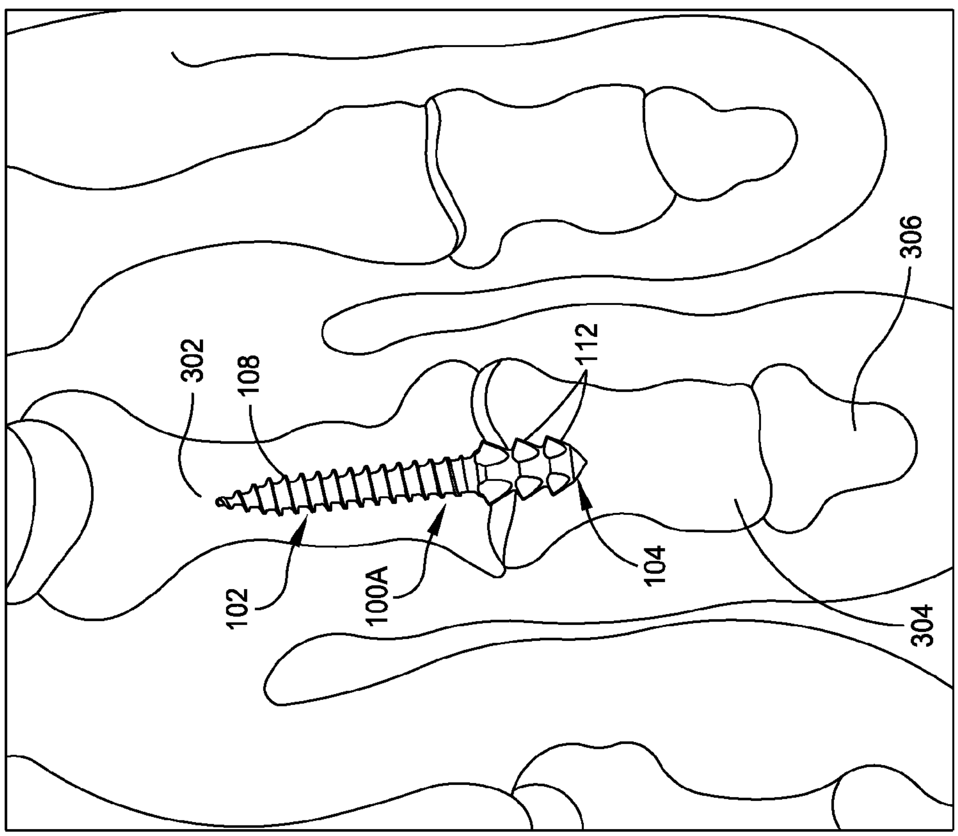


FIG. 46

TWO-WIRE TECHNIQUE FOR INSTALLING HAMMERTOE IMPLANT

FIELD OF DISCLOSURE

The disclosed system and method relate implants. More specifically, the disclosed system and method relate to installing an implant for treating hammer toe.

BACKGROUND

Hammer toe is a deformity of the toe that affects the alignment of the bones adjacent to the proximal interphalangeal (PIP) joint. Hammer toe can cause pain and can lead to difficulty in walking or wearing shoes. A hammer toe can often result in an open sore or wound on the foot. In some instances, surgery can be required to correct the deformity by fusing one or both of the PIP and distal interphalangeal (DIP) joints.

The most common corrective surgery includes the placement of a pin or rod in the distal, middle, and proximal phalangees of the foot to fuse the PIP and DIP joints. The pin or rod is cut at the tip of the toe, externally of the body. A plastic or polymeric ball is placed over the exposed end of the rod, which remains in the foot of the patient until the PIP and/or DIP joints are fused in approximately 6 to 12 weeks. This conventional treatment has several drawbacks such as preventing the patient from wearing closed toe shoes while the rod or pin is in place, and the plastic or polymeric ball can snag a bed sheet or other object due to it extending from the tip of the toe resulting in substantial pain for the patient.

Another conventional implant includes a pair of threaded members that are disposed within adjacent bones of a patient's foot. The implants are then coupled to one another through male-female connection mechanism, which is difficult to install in situ and has a tendency to separate.

Yet another conventional implant has body including an oval head and a pair of feet, which are initially compressed. The implant is formed from nitinol and is refrigerated until it is ready to be installed. The head and feet of the implant expand due to the rising temperature of the implant to provide an outward force on the surrounding bone when installed. However, the temperature sensitive material can result in the implant deploying or expanding prior to being installed, which requires a new implant to be used.

Accordingly, an improved implant for treating hammer toe is desirable.

SUMMARY

In some embodiments, a method includes inserting a first surgical device into an exposed first end of a first bone until a trailing end of the first surgical device is disposed adjacent to the first end of the first bone. A second surgical device is inserted into an exposed first end of a second bone while the first surgical device remains disposed within the first bone. A first portion of an implant is advanced into the second bone while being engaged with a passageway defined by the implant such that the implant is guided by the second surgical device. The second surgical device is removed from the second bone and from its engagement with the implant. The first bone is repositioned such that the first surgical device is aligned with the passageway defined by the implant, and the first bone is forced into engagement with a second portion of the implant.

In some embodiments, a method includes forming an incision to gain access to a joint between first and second bones, flexing the first and second bones such that the first and second bones are disposed at an angle with respect to one another, inserting a first surgical device into the first bone until a first end of the first surgical device is disposed adjacent to a first end of the first bone, and inserting a second surgical device into the second bone while the first surgical device remains disposed within the first bone. A first portion of an implant is advanced into the second bone while a passageway defined by the implant is engaged with the second surgical device such that the implant is guided by the second surgical device. The second surgical device is removed from the second bone and from its engagement with the implant. The first bone is repositioned such that the first surgical device is aligned with the passageway defined by the defined by the implant, and the first bone is forced into engagement with a second portion of the implant.

In some embodiments, a surgical method includes gaining access to a joint between a middle phalange and a proximal phalange, inserting a first end of a first surgical device into a proximal end of the middle phalange, advancing the first surgical device into the middle phalange and a distal phalange until a second end of the first surgical device is disposed adjacent to the proximal end of the middle phalange, and inserting a first end of a second surgical device into a distal end of the proximal phalange while the first surgical device remains disposed within the middle and distal phalanges. A first portion of an implant is advanced into the proximal phalange using the second surgical device as a guide. The second implant is removed. The first surgical device is inserted into a passageway defined by the implant while the first surgical device remains disposed within the middle and distal phalange, and the first surgical device is removed from its engagement with the implant, middle phalange, and distal phalange.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features and advantages of the present invention will be more fully disclosed in, or rendered obvious by the following detailed description of the preferred embodiments of the invention, which are to be considered together with the accompanying drawings wherein like numbers refer to like parts and further wherein:

FIG. **1** is an isometric view of an improved hammer toe implant according to some embodiments;

FIG. **2** is a top side view of the hammer toe implant illustrated in FIG. **1**;

FIG. **3** is a top side view of the blade portion of the hammer toe implant illustrated in FIG. **6**;

FIG. **4** is a sectional view of the hammer toe implant taken along line **3-3** in FIG. **2**;

FIG. **5** is an end on view of the hammer toe implant taken along line **4-4** in FIG. **2**;

FIG. **6** is an isometric view of an improved, cannulated hammer toe implant according to some embodiments;

FIG. **7** is a side view of one example of a driving adapter for use with the hammer toe implants illustrated in FIGS. **1** and **6**;

FIG. **8** is an end view of the driving adapter illustrated in FIG. **7**;

FIG. **9** is a side view of another example of a driving adapter for use with the hammer toe implants illustrated in FIGS. **1** and **6**;

FIG. **10** is an end view of the driving adapter illustrated in FIG. **9**;

FIG. **11**A is an assembly view of a hammer toe implant engaged by a driving adapter;

FIG. 11B is an assembly view of a cannulated hammer toe implant engaged by a cannulated driving adapter;

FIG. 12A illustrates the middle and proximal phalangees of a foot being resected;

FIG. 12B illustrates the middle and proximal phalangees of a foot being resected;

FIG. 13 illustrates a hammer toe implant being driven into a proximal phalange;

FIG. 14 illustrates a middle phalange being drilled or broached;

FIG. 15 illustrates a blade of a hammer toe implant extending from the proximal phalange with the middle phalange having been drilled or broached;

FIG. 16 illustrates a hammer toe implant installed in the middle and proximal phalangees;

FIG. 17 illustrates another example of a driving assembly for installing an implant;

FIG. 18 illustrates a side view of the driving assembly illustrated in FIG. 17;

FIG. 19 is an isometric view of an adapter of the driving assembly illustrated in FIG. 17;

FIG. 20 is an end view of the adapter illustrated in FIG. 19;

FIG. 21 is a cross-sectional view of the adapter taken along line 21-21 in FIG. 20;

FIG. 22 is a cross-sectional view of the adapter taken along line 22-22 in FIG. 20;

FIG. 23 is a plan view of the driving rod of the driving assembly illustrated in FIG. 17;

FIG. 24 is a cross-sectional view of the driving rod taken along line 24-24 in FIG. 23;

FIG. 25 is a cross-sectional view of the fin of the driving rod taken along line 25-25 in FIG. 23;

FIG. 26 is a plan view of driving assembly illustrated in FIG. 17 without the o-ring;

FIG. 27 is a cross-sectional view of the handle taken along line 27-27 in FIG. 26;

FIG. 28A illustrates an implant coupled to the adapter of the driving assembly illustrated in FIG. 17;

FIG. 28B illustrates an implant coupled to the adapter of the driving assembly illustrated in FIG. 17;

FIG. 29 illustrates a hammer toe implant being driven into a proximal phalange;

FIG. 30 illustrates an implant kit comprising a hammer toe implant preloaded in the adapter shown in FIGS. 19-22;

FIG. 31A is an isometric view of an implant kit according to some embodiments whose adapter has an implant receiving end configured to couple to an implant by an O-ring according to the adapter of FIGS. 19, 28A and 28B and having a driver shaft coupling end configured for coupling to the driver shaft by mating male and female threads;

FIG. 31B is an isometric view of an implant kit according to some embodiments whose adapter has an implant receiving end configured to couple to an implant by an O-ring according to the adapter of FIGS. 19, 28A and 28B and having a driver shaft coupling end configured for coupling to the driver shaft by a pair of opposing tabs;

FIG. 31C is a cross-sectional view of an adapter having a driver shaft coupling end illustrated in FIG. 31B and an implant receiving end according to some embodiments;

FIG. 31D is a cross-sectional view of an adapter having a driver shaft coupling end illustrated in FIG. 31A according to some embodiments;

FIG. 32A is an isometric view of an implant kit according to some embodiments whose adapter has an implant receiving end configured to couple to an implant by an O-ring according to the adapter of FIGS. 19, 28A and 28B and having a driver shaft coupling end configured for coupling to the driver shaft by an O-ring;

FIG. 32B is a side view of an adapter has an implant receiving end configured to couple to an implant by an O-ring according to the adapter of FIGS. 19, 28A and 28B and having a driver shaft coupling end configured for coupling to the driver shaft by an O-ring according to some embodiments;

FIG. 32C is a cross-sectional view of an implant kit whose adapter has a driver shaft coupling end for coupling to the driver shaft by an O-ring according to some embodiments;

FIG. 33A is a side view of an implant kit according to some embodiments whose adapter has an implant receiving end configured to couple to an implant by an O-ring according to the adapter of FIGS. 19, 28A and 28B and having a driver shaft coupling end configured for coupling to the driver shaft by an off-set clip;

FIG. 33B is an end perspective view of an adapter having a driver shaft coupling end configured for coupling to the driver shaft by an off-set clip according to some embodiments;

FIG. 33C is a cross-sectional view of an adapter having a driver shaft coupling end configured for coupling to the driver shaft by an off-set clip according to some embodiments;

FIG. 34A is an end perspective view of an adapter having a driver shaft coupling end configured for coupling to the driver shaft by a C-clip according to some embodiments;

FIG. 34B is an end view of an adapter having a driver shaft coupling end configured for coupling to the driver shaft by a C-clip according to some embodiments;

FIG. 34C is an end view of an adapter having a driver shaft coupling end configured for coupling to the driver shaft by a C-clip according to some embodiments;

FIG. 34D is cross-sectional view of an implant kit according to some embodiments having a driver shaft coupling end configured for coupling to the driver shaft by a C-clip;

FIG. 34E is a side view of a driver shaft configured for coupling to a driver shaft-coupling end of the adapter illustrated in FIG. 34D according to some embodiments;

FIG. 35A is an isometric view of some embodiments of an implant kit comprising an adapter that is configured for coupling to an hammer toe implant using a collet;

FIG. 35B is an isometric view of some embodiments of an implant kit comprising an adapter that is configured for coupling to an hammer toe implant using a collet and showing a hammer toe implant received in the adapter;

FIG. 35C is an isometric view of some embodiments of an implant kit comprising an adapter that is configured for coupling to an hammer toe implant using a collet;

FIG. 35D is a an end view of the implant kit illustrated in FIG. 35B;

FIG. 35E is cross-sectional view of the implant kit taken along line 25-25 in FIG. 35D;

FIG. 35F is cross-sectional view of the implant kit taken along line 25-25 in FIG. 35D;

FIG. 36A is an isometric view of another example of hammer toe implant according to some embodiments;

FIG. 36B is a top side view of the hammer toe implant illustrated in FIG. 36A;

FIG. 37 is a flow diagram of one example of method of installing an implant in accordance with some embodiments;

FIG. 38 illustrates a joint being accessed using a cutting tool in accordance with some embodiments;

FIG. 39 illustrates the middle and proximal phalangees of a foot being resected in accordance with some embodiments;

FIG. **40** illustrates a surgical device being inserted through the middle and distal phalanges in accordance with some embodiments;

FIG. **41** illustrates a second surgical device being inserted to a proximal phalange while the first surgical device remains disposed within the middle and distal phalanges in accordance with some embodiments;

FIG. **42**A illustrates an implant and surgical device being disposed within the proximal phalange while the first surgical device remains disposed within the middle and distal phalanges in accordance with some embodiments;

FIG. **42**B illustrates the implant being disposed within the proximal phalange after the second surgical device has been removed and while the first surgical device remains disposed within the middle and distal phalanges in accordance with some embodiments;

FIG. **43** illustrates the middle phalange having been pressed into engagement with the implant using the first surgical device as a guide in accordance with some embodiments;

FIG. **44** illustrates the first surgical device being advanced into the proximal phalange and metatarsal in accordance with some embodiments;

FIG. **45** illustrates one example of an end of the first surgical device having a blunted end while disposed within the middle, proximal, and distal phalanges and within the implant in accordance with some embodiments; and

FIG. **46** illustrates a hammer toe implant installed in the middle and proximal phalanges in accordance with some embodiments.

DETAILED DESCRIPTION

This description of preferred embodiments is intended to be read in connection with the accompanying drawings, which are to be considered part of the entire written description. The drawing figures are not necessarily to scale and certain features of the invention can be shown exaggerated in scale or in somewhat schematic form in the interest of clarity and conciseness. In the description, relative terms such as "horizontal," "vertical," "up," "down," "top," and "bottom" as well as derivatives thereof (e.g., "horizontally," "downwardly," "upwardly," etc.) should be construed to refer to the orientation as then described or as shown in the drawing figure under discussion. These relative terms are for convenience of description and normally are not intended to require a particular orientation. Terms including "inwardly" versus "outwardly," "longitudinal" versus "lateral," and the like are to be interpreted relative to one another or relative to an axis of elongation, or an axis or center of rotation, as appropriate. Terms concerning attachments, coupling, and the like, such as "connected" and "interconnected," refer to a relationship wherein structures are secured or attached to one another either directly or indirectly through intervening structures, as well as both movable or rigid attachments or relationships, unless expressly described otherwise. The term "operatively connected" is such an attachment, coupling or connection that allows the pertinent structures to operate as intended by virtue of that relationship.

FIG. **1** illustrates one example of an improved implant **100** for treating hammer toe. As shown in FIG. **1**, implant **100** includes a threaded portion **102** and a blade portion **104**, which are connected together at an engagement portion **106**. In some embodiments, implant **100** has a substantially linear geometry. In some embodiments, implant **100** has an overall length of approximately 19 mm (approximately 0.75 inches) (e.g. 18.9-19.1 mm (0.74-0.76 inches)). In some embodiments, blade portion **104** can be disposed at angle with respect to a longitudinal axis defined by the threaded portion **102**. The angle can be between zero and 45 degrees, and more particularly between approximately five and fifteen degrees, although one skilled in the art will understand that implant **100** can have other dimensions and be provided in different sizes. For example, implant **100** can be provided in lengths of 16 mm and 22 mm, to name a few potential lengths.

In some embodiments, threaded portion **102** includes a plurality of threads **108** disposed along its entire length, which can be approximately 13 mm (approximately 0.5 inches) (e.g. 12.9-13.1 mm (0.49-0.51 inches)) although one skilled in the art will understand that threaded portion **102** can have other dimensions and be provided in different sizes. For example, threaded portion **102** can be provided in lengths of 10 mm and 15 mm, to name a few potential lengths. The tip **110** of threaded portion **102** can be pointed to facilitate the advancement of threads **108** into bone. Threads **108** can have a maximum outer diameter of approximately 2 mm (approximately 0.08 inches), although one skilled in the art will understand that thread portion **102** can have other dimensions and be configured to be received within a phalange bone of a person. For example, threads can have an outer diameter of approximately 2.4 mm and 1.6 mm, to name a few potential possibilities.

As shown in FIGS. **1-4** and **6**, blade portion **104** can have a substantially cylindrical cross-sectional geometry. One skilled in the art will understand that blade portion **104** can have other cross-sectional geometries. In some embodiments, blade portion **104** can have a taper defined by a plurality of blades **112**. For example, as best shown in FIGS. **2** and **3**, the taper of blade portion **104** can be at an angle relative to the longitudinal axis defined by the elongated central portion of implant **100**. In some embodiments, the taper is at an angle (θ_T) between 1 and 10 degrees relative to the longitudinal axis defined by the elongated central portion of implant **100**. For example, the taper can be at an angle (θ_T) of approximately 5 degrees (e.g. 4.9-5.1 degrees) degrees relative to the longitudinal axis defined by the elongated central portion of implant **100**. In some embodiments, blade portion **104** includes a taper along its diameter defined by the plurality of blades **112**. In the illustrated embodiments of FIGS. **2**, **3** and **5**, the plurality of blades **112** include a first blade **112** having a first diameter disposed proximate the engagement portion **106** and a second blade **112** having a second diameter smaller than the first diameter disposed proximate a terminating end **118** of the blade portion **104**. In some embodiments, the first diameter can be approximately 5 mm (approximately 0.20 inches) (e.g. 4.9-5.1 mm) (0.19-0.21 inches) and the second diameter can be approximately 4.5 mm (approximately 0.18 inches) (e.g. 4.4-4.6 mm) although one skilled in the art will understand that the plurality of blades **112** can have other diameters and other dimensions. For example, the first diameter can be provided as in lengths of 4 mm and 6 mm, to name a few potential diameters. The inventors have found that the tapered blade portion **104** permits each successive blade **112** of blade portion **104** to achieve interference with bone during insertion which enhances fixation of the blade portion **104** compared to a non-tapered blade portion **104**. In the illustrated embodiment, the blades **112** of blade portion **104** include a valley **126** between blades **112** and the teeth portions **114** of each blade **112**. In some embodiments, valley **126** of teeth portions **114** of each blade **112** is substantially the same. In other embodiments, the valleys

126 of teeth portions **114** vary as the respective diameters of the successive blades are tapered.

In some embodiments, the terminating end **118** of blade portion **104** is a point, although one skilled in the art will understand that blade portion **104** can have a terminating end of other dimensions, sizes and/or shapes. In the illustrated embodiment of FIGS. **3** and **6**, the terminating end **118** of blade portion **104** is cannulated. In various embodiments (FIGS. **3** and **6**), the blade portion **104** and threaded portion **102** of implant **100** are cannulated. In some embodiments, implant **100** (FIGS. **3**, **6**, **11**B) includes a groove **109** sized and configured to receive a k-wire, pin, or other surgical device or instrument that extends along the length of implant **100** in a direction that is parallel to a longitudinal length defined by implant **100**. In some embodiments, the taper of blade portion **104** can be defined by the plurality of blades **112** having successively smaller diameters between a blade **112** disposed proximate engagement portion **106** and a blade **112** disposed proximate terminating end **118** of the blade portion **104**.

In various embodiments, each blade **112** of the plurality of blades **112** of blade portion **104** include a plurality of grooved portions **116** and a plurality of teeth portions **114** to form a substantially cruciform cross-sectional geometry (FIG. **5**). In the illustrated embodiment of FIG. **5**, each blade **112** of blade portion **104** having a substantially cylindrical cross-section includes a plurality of substantially rounded grooved portions **116** formed along an axis parallel to a longitudinal axis of blade portion **104** and a plurality of teeth portions **114**. As shown in FIGS. **1-5** and **6**, blade portion **104** can have a substantially cylindrical cross-sectional geometry including a plurality of blades **112** having respective substantially cruciform cross-sectional geometries defined by a grooved portion **116** being disposed in each quadrant (**112***a-d*) of each blade **112**. In some embodiments, each blade **112** of blade portion **104** includes a pair of opposing grooved portions **116** (e.g. in quadrants **112***b* and **112***d* and in quadrants **112***a* and **112***c* respectively) to form a substantially cruciform cross-sectional geometry. As shown in FIG. **5**, the grooved portions **116** of each pair of opposing grooved portions **116** (e.g. in quadrants **112***a* and **112***c* and **112***b* and **112***d* respectively) are substantially symmetrical. In the illustrated embodiment of FIG. **5**, the grooved portions **116** disposed in each quadrant (**112***a-d*) of each blade **112** are substantially symmetrical and the teeth portions **114** of each blade **112** are substantially symmetrical.

As shown more clearly in the illustrated embodiments of FIGS. **1**, **3**, **5** and **6**, each blade **112** of blade portion **104** includes no flat surfaces. In some embodiments, a centerline of grooved portion **116** of each blade **112** of blade portion **104** is dimensioned such that it is tangent to respective diameters measured at the intersections of grooved portion **116** and the respective teeth portions **114**. In the illustrated embodiments, grooved portions **116** are concave in shape and teeth portions **114** are convex in shape. In the illustrated embodiments, the respective surfaces of each blade **112** are rounded. In some embodiments, teeth portions **114** are serrated.

In some embodiments, engagement portion **106** can include a pair of protrusions extending from opposite sides of implant **100** and having rounded outer edges. In some embodiments, for example as shown in FIG. **2**, the sides of the protrusions of engagement portion **106** can be substantially parallel with each other. In some embodiments, at least a portion of the implant **100** is cannulated (FIGS. **3**, **6**). The inventors have found that a cannulated implant **100** design can permit surgeons to stabilize joints (e.g. a metatarsal phalangeal joint (MPJ)) during a surgical procedure.

Implant **100** is configured to be installed using a driving adapter **200** such as the one illustrated in FIGS. **7-10**. The driving adapter **200** has an elongated body **202** having a proximal end **204** and a distal end **206**. Body **202** of driving adapter **200** can have a circular cross-sectional geometry, although one skilled in the art will understand that body **202** can have other cross-sectional geometries including, but not limited to, triangular, rectangular, pentagonal, and hexagonal to name a few.

Proximal end **204** can be substantially solid and have a rounded tip **208**. In some embodiments, proximal end **204** and distal end **206** can be cannulated such as, for example, to receive a k-wire. Distal end **206** can define a slot **210** sized and configured to receive blade portion **104** of implant **100** therein. In some embodiments, slot **210** can have a cylindrical cross-sectional geometry and have a depth that is sufficient to receive the entire blade portion **104** of implant **100** such that distal edges **212** of slot **210** contact the protrusions of engagement portion **106**. In some embodiments, slot **210** can have a cylindrical, cruciform cross-sectional geometry and have a depth that is sufficient to receive the entire blade portion **104** of implant **100** such that distal edges **212** of slot **210** contact the protrusions of engagement portion **106**. However, one skilled in the art will understand that slot **210** can have other cross-sectional geometries and dimensions. Slot **210** can extend through side walls **214** of body **202** as shown in FIGS. **7** and **8**, or side walls **214** can completely enclose slot **210** as shown in FIGS. **9** and **10**.

If the driving adapter **200** is to be used with an implant **100** having a substantially linear lengthwise geometry such as the implant **100** illustrated in FIGS. **1-6**, then slot **210** can extend in a direction that is substantially parallel to an axis defined by body **202** of driving adapter **200**. If driving adapter **200** is to be used with an implant **100** having a blade portion **104** that extends at an angle with respect to an axis defined by elongated threaded portion **102**, then slot **210** can extend from distal edges **212** at an angle with respect to an axis defined by the length of body **202** such that elongated threaded portion **102** of implant **100** is linearly aligned with body **202** of driving adapter **200** as shown in FIGS. **11**A and **11**B. For example, if blade portion **104** of implant **100** extends at a ten degree angle with respect to an axis defined by elongated threaded portion **102**, then slot **210** of driving adapter **200** can extend at a ten degree angle with respect to a longitudinal axis defined by body **202** such that threaded portion **102** of implant **100** and body **202** of driving adapter **200** are substantially linearly aligned.

A method of installing implant **100** in the proximal interphalangeal joint (PIP) **300** is described with reference to FIGS. **12**A-**16**. However, one skilled in the art will understand that the technique for installing the implant **100** can be applied to other joints such as, for example, the distal interphelangeal (DIP) joint between middle phalange **304** and distal phalange **306**. As shown in FIGS. **12**A and **12**B, an incision is made to open the PIP joint **300** and a cutting tool **400** having a blade **402** can be used to resect adjacent faces of proximal phalange **302** and middle phalange **304**. The resected surfaces of proximal phalange **302** and middle phalange **304** can be debrided as understood by one skilled in the art.

Blade portion **104** of implant **100** can be disposed within slot **210** of driving adapter **200** as shown in FIGS. **11**A and **11**B. In some embodiments, the body **202** of driving adapter **200** can be cannulated. In some embodiments, a k-wire, pin or other suitable surgical device can be inserted into the middle phalange **304** and driven through distal phalange and out of the end of the toe (not shown). A k-wire can be inserted such that a trailing end is disposed within middle phalange **304** or otherwise positioned with respect to the joint such that cannulated implant **100** can be driven into proximal phalange **302**. In various embodiments, the body **202** of driving adapter **200** can be secured in a chuck **412** of a drill **410** or other driving instrument as shown in FIG. **13**. Drill **410** or other driving instrument is used to drive the threaded portion **102** of implant **100** into the resected surface of proximal phalange **302**. With the threaded portion **102** of implant **100** disposed within proximal phalange **302**, driving adapter **200** can be disengaged from blade portion **104** of implant **100**.

Middle phalange **304** can be predrilled or broached using drill **410** to create a hole **308** as shown in FIGS. **14** and **15**. The predrilled or broached middle phalange **304** is then repositioned such that the predrilled hole or broach **308** aligns with the blade portion **104** of implant **100**. In some embodiments, a dimension (e.g. diameter or width) of the predrilled hole or broach **308** is less than a dimension of blade portion **104** to permit a first blade **112** to achieve interference with the bone and enhance fixation of blade **104**. For example, in some embodiments, "valley-to-valley" dimension of blade portion **104** (e.g. the diametrical dimension of blade portion **104** between blades **112**). In some embodiments, a k-wire or other suitable surgical device is disposed within middle phalange **304** can be aligned with groove **109** of cannulated implant **100** (FIGS. **3**, **6**, **11**B) disposed within proximal phalange **302**. In various embodiments, the middle phalange **304** can be then pressed into engagement with the blade portion **104** as shown in FIG. **16**. Serrated teeth portions or edges **114** of blade portion **104** help to maintain the engagement between middle phalange **304** and blade portion **104** of implant **100**. In various embodiments, a k-wire or other suitable surgical device can be advanced into the joint, into and through middle phalange **302**, into the respective metatarsal and through cannulated implant **100**. In various embodiments, the k-wire or other suitable surgical device can remain within the patient for a period of time, e.g. minutes, hours, days or months, and can then be removed to leave behind cannulated implant **100**.

FIGS. **17-27** illustrate some embodiments of a driver assembly **500** for installing an implant into bone. As shown in FIGS. **17** and **18**, driver assembly **500** includes an adapter **502** coupled to a driving rod **516** onto which a handle **534** is over-molded or otherwise coupled. Adapter **502** includes a body **504** with a substantially rectangular side profile comprising side walls **506-1**, **506-2**, **506-3**, and **506-4** (collectively referred to as "side walls **506**") and a pair of end walls **508-1**, **508-2** (collectively referred to as "end walls **508**") having a substantially square geometry as best seen in FIGS. **19-22**.

Body **504** defines a recess **510** along the length of side walls **506**. Recess **510** is dimensioned such that an o-ring **544** (FIGS. **17** and **18**) can be received therein. Additionally, recess **510** is located along side walls **506** at a distance from end walls **508** such that recess **510** is aligned with a valley **126** of teeth portions **114** along the circumference of blade portion **104**.

End wall **508-1** defines an aperture **512** (FIG. **20**) having a geometry that complements the cross-sectional geometry of blade portion **104** of implant **100**. For example, if implant **100** has a cylindrical, cruciform straight blade portion **104** as illustrated in FIG. **2**, then aperture **512** can extend approximately parallel to the lengthwise direction of side walls **506** (FIGS. **21-22**). If the blade portion **104** of implant **100** is angled (not shown), then aperture **512** can extend from wall **508-1** at an angle relative to the plane defined by side wall **506-2** or **506-4** as will be understood by one skilled in the art. In some embodiments, aperture **512** has a depth that is greater than or equal to a length of blade portion **104** such that blade portion **104** can be received within body **504** and engagement portion **106** abuts end wall **508-1**. Similarly, end wall **508-2** defines an aperture that is sized and configured to receive an end of elongated driving rod **516** therein.

As best seen in FIGS. **23-25**, driving rod **516** includes a fin **518** disposed at a first end **520**. Fin **518** disposed at end **520** of driving rod **516** has a rectangular shape and is sized and configured to be received within aperture **512** of adapter **502**. Fin **518** defines a slot **522**, which is sized and configured to receive a pin (not shown) for cross-pinning driving rod **516** to adapter **502**. In some embodiments, end **520** can have other cross-sectional geometries including, but not limited to, triangular, square, and pentagonal, to name a few possibilities, that are configured to be received within aperture **514**. Adapter **502** can be over-molded onto the end of driving rod **516**. However, one skilled in the art will understand that adapter **502** can be cross-pinned or otherwise coupled to driving rod **516**.

The opposite end **524** of driving rod **516** defines a pair of flats **526**, **528**, which are disposed on opposite sides of driving rod **516**. As best seen in FIG. **23**, flat **526** extends from tip **530** and is linearly spaced from flat **528**, which is disposed at a greater distance from tip **530** than flat **526**. However, one skilled in the art will understand that flats **526**, **528** can be disposed at other positions along driving rod **516**. Flats **526**, **528** are configured to provide a contact surface for coupling to handle **532** (FIG. **26**), which can be over-molded onto driving rod **516**, such that rotation of handle **532** is translated to driving rod **516**.

Turning now to FIGS. **26** and **27**, handle **532** has an elongated body **534** that includes a plurality of ribs **536** that extend in a longitudinal direction along body **534** to provide a gripping surface for a user. As best seen in FIGS. **17** and **22**, a smooth surface **538** interrupts circumferential ridges **540**, which are disposed adjacent to proximal end **542** also for providing a gripping surface for a user.

Driver assembly **500** can be provided in a kit with a first adapter **502** for use with a straight implant **100** and a second adapter for use with an angled implant **100**. A plurality of implants **100** of different sizes can also be provided in the kit. The kit can be used in an operation similar to the operation described above with respect to FIGS. **12**A-**16**.

Blade portion **104** of implant **100** is disposed within aperture **512** of adapter **502** as shown in FIGS. **28**A and **28**B. With blade portion **104** disposed within aperture **512**, an o-ring **544** (FIGS. **17** and **18**) is placed in recess **510** defined by adapter **502** and within a valley **126** of serrated edges **112** along the top and bottom sides **114**, **116** of blade portion **104**. O-ring **544** secures implant **100** to adapter **502** such that implant does not move axially out of aperture **512**.

Once implant **100** is secured to adapter **502**, the surgeon uses handle **534** to manually drive threaded portion **102** of implant **100** into the resected surface of proximal phalange **302** as illustrated in FIG. **29**. Implant **100** is driven into proximal phalange **302** until engagement portion **106** abuts proximal phalange **302**. Implant **100** is decoupled from adapter **502** by axially pulling handle **534** away from implant **100** with sufficient force to flex o-ring **544** and separate adapter **502** from implant **100**.

Middle phalange **304** can be predrilled or broached using drill **410** to create a hole **308** as shown in FIGS. **14** and **15**.

The predrilled or broached middle phalange **304** is then repositioned such that the predrilled hole or broach **308** aligns with the blade portion **104** of implant **100**. The middle phalange **304** is then pressed into engagement with the blade portion **104** as shown in FIG. **16**. Serrated teeth portions **114** of blade portion **104** help to maintain the engagement between middle phalange **304** and blade portion **104** of implant **100**.

The implant described above can advantageously be installed through a small incision as described above. Additionally, the improved implant is completely disposed within a toe of a patient, which prevents the implant from being caught on bed sheets or other objects like the conventional pins.

According to an aspect of the present disclosure, the implant can be preloaded into an adapter and provided as an implant kit. Various embodiments of such an implant kit will be described below.

FIG. **30** is a view of the implant kit **1000** in which the implant **100**, **100**A is preloaded into the adapter **502**. FIG. **30** is viewed from within the plane of FIGS. **28**A and **28**B so that the view shows the full circumference of the blade portion **104**, **104**A. In this view of FIG. **30**, with the blade portion **104**, **104**A fully inserted into the adapter **502**, **502**A, an elastic O-ring **544** (also shown in FIGS. **17** and **18**) placed in the groove **510** retains the implant **100**, **100**A in the adapter **502**, **502**A by preventing the implant from sliding out of the adapter. The cross-sections of the O-ring is shown in FIG. **30**. The groove **510** is cut into the adapter with a sufficient depth so that when the O-ring **544** is placed therein the O-ring is positioned within the valley **126** between two adjacent teeth portions **114** about the circumference of the blade portion **104**, **104**A, as shown in FIG. **30**. Because the O-ring **544** is elastic, one can push the blade portion **104**, **104**A of the implant into the adapter with sufficient force for one or more of the teeth portions **114** to push past the O-ring **544** when assembling the implant kit **1000**. Once the implant kit **1000** is assembled, however, the O-ring **544** secures and retains the implant **100**, **100**A in the adapter **502** until one intentionally pulls off the adapter **502** after the implant is driven into a bone.

In use, the surgeon would attach the implant kit **1000** to the driver tool **500** to manually drive the threaded portion **102** of the implant **100**, **100**A into the resected surface of proximal phalange **302** as illustrated in FIG. **29**. The implant **100**, **100**A is driven into the proximal phalange **302** until engagement portion **106** abuts the proximal phalange **302**. The implant **100**, **100**A is then decoupled from the adapter **502** by axially pulling the adapter **502** away from the implant **100**, **100**A with sufficient force to push the O-ring **544** outward and separate the adapter **502** from the implant **100**, **100**A. Referring to FIGS. **31**A through **35**F, various embodiments for removably coupling the implant kits disclosed above to a driver shaft **516** of a driver tool **500** will be described. FIGS. **31**A-**31**D are various views of some embodiments of an adapter such as the adapter **502** of FIGS. **28**A, **28**B, and **30** having a driver shaft coupling end configured for coupling to the adapter-engaging end **517***a*, **517***b* of the driver shaft. The driver shaft coupling end of the adapter **502** is provided with the longitudinally extending bore **514**, configured for receiving the adapter-engaging end **517***a*, **517***b*, and a pair of opposing tabs **541**, **542** extending longitudinally in the direction away from the implant engaging end. FIG. **31**A shows a driver shaft **516** whose adapter-engaging end **517***a* is configured with screw threads. In this embodiment, the driver-engaging end of the adapter **502** is configured to threadably couple to the adapter-engaging end **517***a* of the driver shaft **502** and the tabs **541**, **542** provide additional locking mechanism. FIG. **31**B shows a driver shaft **516** whose adapter-engaging end **517***b* is configured with a magnetic tip. In this embodiment, the driver-engaging end of the adapter **502** is configured to magnetically couple to the adapter-engaging end **517***b* and the tabs **541**, **542** provide additional locking mechanism. The adapter **502** would then be provided with a magnet or a piece of magnetic material **503** for magnetically coupling to the adapter-engaging end **517***b*.

FIGS. **31**C and **31**D are cross-sectional views of the adapter **502** showing the driver-engaging end. FIG. **31**C shows the profile of the tabs **541** and **542** and the bore **514** for receiving the adapter-engaging end **517** of the driver shaft. If the adapter **502** is intended for use with the driver shaft **516** of the embodiment shown in FIG. **31**A, the bore **514** is tapped with screw thread for threadably engaging the threaded adapter-engaging end **517***a*. If the adapter **502** is intended for use with the driver shaft **516** of the embodiment shown in FIG. **31**B, the bore **514** is provided with a magnet **530** for engaging the magnetized tip of the adapter-engaging end **517***b*.

The tabs **541**, **542** and the adapter-engaging end **517***a*, **517***b* are configured for further mechanical coupling. In the illustrated example, the tabs **541**, **542** are provided with bumps **550** and the adapter-engaging end **517***a*, **517***b* of the driver shaft is provided with corresponding cutouts **560** for mating with the bumps **550**.

Shown in FIGS. **32**A-**32**C are various views of an implant kit **1040** comprising an adapter **1502** and an implant **100** according to some embodiments. The implant **100** is removably coupled to the adapter **1502** at the adapter's implant-receiving end **1503** by a first O-ring **544** in the same manner as with the adapter **502** shown in FIGS. **19**, **28**A, **28**B and **30**. The adapter **1502** has a circumferential groove **1510**, in which the first O-ring **544** is provided, in the outer surface of the adapter in proximity to the implant-receiving end **1503**. As with the adapter embodiment **502**, the adapter **1502** comprises a slot provided in the implant-receiving end **1503** that receives the blade portion **104** of the implant **100**. The adapter **1502** also has a driver shaft coupling end **1504** configured for removably coupling to the driver shaft **516** by a second O-ring **546**. The driver shaft coupling end **1504** is provided with a longitudinally extending bore **1514** for receiving the adapter-engaging end **1517** of the driver shaft **516**. The driver shaft coupling end **1504** is also provided with a second circumferential groove **1512** in which the second O-ring **546** is disposed. The adapter-engaging end **1517** has a cross-section that is larger than the inner diameter of the second O-ring **546** but has a turned down section **1518** that has a reduced cross-section for accommodating the second O-ring **546** when the adapter-engaging end **1517** is inserted into the bore **1514** as shown in FIG. **32**C. When the adapter-engaging end **1517** is inserted into the bore **1514**, the turned down section **1518** and the second circumferential groove **1512** align so that the second O-ring **546** rests in the turned down section **1518**. The second O-ring **546** thus provides an interference with the adapter-engaging end **1517** to prevent the adapter **1502** and the driver shaft **516** from decoupling without exerting some force.

FIGS. **33**A-**33**C are various views of an adapter **2502** that can be used in an implant kit **1050** according to some embodiments of the present disclosure. The adapter **2502** has an implant receiving end **2503** configured to couple to an implant **100** by an O-ring **544** according to the adapter of FIGS. **19**, **28**A and **28**B and a driver shaft coupling end **2504** configured for coupling to the driver shaft **516** by an off-set clip **2515**. The driver shaft coupling end **2504** has a longitudinally extending bore **2514** for receiving an adapter-engaging end **2517** of the driver shaft **516**. The off-set clip **2515** is cantilevered to the adapter having a cantilever portion **2515***a* connected to the adapter body and a locking portion **2515***b* extending orthogonal to the cantilever portion **2515***a*. The locking portion **2515***b* is provided with a through hole **2516** for the adapter-engaging end **2517** of the driver shaft **516**. The through hole **2516** and the bore **2514** are off-set to enable the locking function. The adapter-engaging end **2517** is provided with a groove or a cutout **2518** on one side for removably engaging the off-set clip **2515**. To insert the adapter-engaging end **2517** into the adapter, the user pushes the off-set clip **2515** in the direction shown by the arrow P in FIG. **33**C, which is a longitudinal cross-sectional view of the adapter **2502**. That will deflect the cantilever portion **2515***a* in the direction P and bring the through hole **2516** in linear alignment with the bore **2514** so that the adapter-engaging end **2517** can be inserted through the through hole **2516** and the bore **2514**. Once the adapter-engaging end **2517** is fully inserted, the off-set clip **2515** is released to its normal off-set position as shown in FIG. **40**C. The off-set position of the locking portion **2515***b* keeps the locking portion **2515***b* seated within the cutout **2518** keeping the driver shaft **516** coupled to the adapter **2502**. The off-set clip can be configured so that in the configuration shown in FIG. **33**C, the locking portion **2515***b* maintains a force against the cutout **2518** in the direction opposite the arrow P. To remove the adapter **2502** from the adapter-engaging end **2517**, the off-set clip **2515** is pushed in the direction of the arrow P shown in FIG. **33**C bringing the through hole **2516** and the bore **2514** into longitudinal alignment and thus removing the interference between the locking portion **2515***b* and the cutout **2518**. In some embodiments, the adapter-engaging end **2517** may simply be straight without the cutout **2518** structure. In that embodiment, the urging of the locking portion **2515***b* against the straight adapter-engaging end **2517** in the direction opposite the arrow P will provide sufficient frictional interference to keep the driver shaft **516** and the adapter **2502** coupled.

FIGS. **34**A-**34**E are various views of the driver shaft coupling end **3504** of an adapter **3502** that is configured for removably coupling to the implant **100** to form an implant kit according to some embodiments. The implant-receiving end of the adapter **3502** is configured to couple to the implant by an O-ring **544** according to the adapter of FIGS. **19**, **28**A and **28**B. The driver shaft coupling end **3504** is configured to removably couple to the adapter-engaging end **3517** of the driver shaft **516** by a C-clip **3550**. The C-clip **3550** is generally shaped like a letter C and has two prongs **3550***a* and **3550***b* joined at one end and open at the opposite end. The driver shaft coupling end **3504** of the adapter **3502** is provided with a bore **3514** for receiving the adapter-engaging end **3517**. The driver shaft coupling end **3504** is further configured with a pair of slots **3512** for receiving the C-clip **3550** and oriented orthogonal to the longitudinal axis of the adapter **3502**. FIG. **34**B is an end view of the adapter assembly viewed from the driver shaft coupling end **3504** showing the C-clip **3550** clipped on to the adapter **3502** by sliding the two prongs **3550***a*, **3550***b* into the pair of slots **3512**. The pair of slots **3512** are cut into the adapter **3502** sufficiently deep to overlap with the bore **3514** so that when the C-clip **3550** is clipped on to the adapter **3502**, interference tabs **3551** on each of the two prongs **3550***a*, **3550***b* protrude into the bore **3514** as shown in FIG. **34**B. When the adapter-engaging end **3517** of the driver shaft **516** is inserted into the bore **3514** and locked with the C-clip **3550** as shown in the longitudinal cross-sectional view of FIG. **34**E, the interference tabs **3551** reside in the corresponding slots **3518** provided in the adapter-engaging end **3517** and prevent the adapter **3502** and the driver shaft **516** from decoupling. In this embodiment, the interference tabs **3551** are oriented substantially parallel to one another. In one preferred embodiment, the interference tabs **3551** can be oriented in a slant so that the interference tabs **3551** are tapered towards the open end of the C-clip **3550**. The tapered interference tabs **3551** makes is easier to insert the C-clip **3550** over the adapter-engaging end **3517**.

FIGS. **35**A-**35**F are various views of some embodiments of an implant kit **1030** comprising an adapter **2600** configured for coupling to a hammer toe implant **100** using a thread-biased collet **2650**. The adapter **2600** comprises a sleeve **2602** and the collet **2650**. The sleeve **2602** has openings at each end and a bore **2615** longitudinally extending between the two openings. As shown in FIGS. **35**A and **35**B, sleeve **2602** can include a plurality of ribs that extend in a longitudinal direction along sleeve **2602** to provide a gripping surface for a user. The collet **2650** is received in the bore **2615**. The sleeve **2602** has a first end **2605** that forms one of the openings.

Referring to FIG. **35**A, the collet **2650** is generally cylindrical in shape and comprises an implant receiving portion **2657** and a threaded portion **2660**. The threaded portion **2660** is provided with screw threads **2663**. The implant receiving portion **2657** has an implant-receiving opening **2612** for receiving the blade portion **104** of the implant **100**. The implant-receiving opening **2612** is defined by collet segments **2651** which are defined by slots **2652** extending from the implant-receiving end towards the threaded portion **2660**. This example of a collet has two collet segments **2651**. The implant receiving portion **2657** is flared in its outer circumference so that the diameter of the receiving portion **2657** increases towards the implant-receiving end of the collet. FIG. **35**B shows the collet **2650** with the implant **100** received in the slots **2652**. FIG. **35**C shows the collet with an indicated direction of rotation L to drive the sleeve **2602** onto the threaded portion **2660** to retain the implant **100** within implant receiving portion **2657**. In various embodiments, the refraction and extension of the collet **2650** is enabled by turning the sleeve **2602** about a longitudinal axis relative to the collet **2650** thus engaging the screw threads **2607** and **2663**. In some embodiments, sleeve **2602** is driven by hand in direction of rotation L to retain implant **100** within implant receiving portion **2657** pre-implantation and in an opposite direction of L to release implant **100** post-implantation.

FIG. **35**D is an end view of the adapter **2600** illustrated in FIGS. **35**A-**35**C and shows the implant **100** received in the implant receiving end **2657** and slots **2652**. The implant-receiving opening **2612** of implant receiving portion **2657** has a geometry that complements the cross-sectional geometry of blade portion **104** of implant **100** and is defined by collet segments **2651** which are defined by slots **2652**. For example, if implant **100** has a cylindrical, cruciform straight blade portion **104** as illustrated in FIG. **2** and FIG. **35**A, then implant-receiving opening **2612** can extend approximately parallel to the lengthwise direction of collet **2650**. If the blade portion **104** of implant **100** is angled (not shown), then implant-receiving opening **2612** can extend from end **2603** at an angle relative to the plane defined by collet **2650** as will be understood by one skilled in the art. In various embodiments, as shown in FIGS. **35**A and **35**D, collet segments

2651 of implant receiving end 2657 include radii features to complement radii features of the cylindrical, cruciform blade portion 104.

Referring now to FIGS. 35E and 35F, the bore 2615 has a screw threaded portion 2607 and a main portion 2605. The threaded portion 2607 is configured to threadably engage the threads 2663 of the collet 2650. The main portion 2605 has a sufficiently large diameter to accommodate a substantial portion of the implant receiving portion 2657 of the collet 2650 without imposing any mechanical interference. The main portion 2605 terminates at the first end 2603 where the opening formed therein has a diameter smaller than the maximum diameter of the flared implant receiving portion 2657. This configuration allows the collet segments 2651 to be constricted by the first end 2603 when the collet 2650 is retracted into the sleeve 2602 in the direction R shown in FIG. 35F and close in on the blade portion 104 of the implant 100, thus, retaining the implant. Conversely, the implant 100 can be released from the adapter 2600 by extending the collet 2650 outward from the sleeve 2602 in the direction E shown in FIG. 35F. In some embodiments, and as shown in FIG. 35F, sleeve 2602 includes an internal taper to interface with an external taper of the implant receiving portion 2657 of collet 2650.

FIGS. 36A and 36B illustrate one example of an implant 100A that can be used with the two-wire insertion technique described herein. Implant 100A is identified to implant 100 except that implant 100A includes a central passageway 101 that extends through the entire length of implant 100A. Descriptions of the features of implant 100A that are identical to the features of implant 100 are not repeated.

FIG. 37 is a flow diagram of one example of installing a hammer toe implant using a two-wire technique in accordance with some embodiments. Method 2000 depicted in FIG. 37 is described with reference to FIGS. 38-45, which illustrate various steps of installing a hammer toe implant. Although the following descriptions are provided with respect to installing implant 100A, it will be appreciated that implants having other shapes and configurations can be used so long as they include a passageway for accommodating a k-wire as will be apparent after reading the following description. One example of such an alternative implant is disclosed in commonly assigned U.S. patent application Ser. No. 14/043,105, filed Oct. 1, 2013 and entitled “Hammer Toe Implant and Method,” the entirety of which is incorporated by reference herein. As will be appreciated by one of ordinary skill in the art, the implants can have other fixation features. For example, both ends of the implant can have blades instead of one blade portion and one threaded portion. In some embodiments, the implant can include a blade or threaded portion at one end and an expanding portion (e.g., divergent legs or arms) at the opposite end.

Further, although method 2000 is described as installing an implant in the bones of a proximal interphelangeal joint (PIP) 300, i.e., the joint between proximal phalange 302 and middle phalange 304, one of ordinary skill in the art will understand that the technique may be applied to other joints, such as, for example, the distal interphelangeal (DIP) joint, i.e., joint 308 between middle phalange 304 and distal phalange 306.

At block 2002 of FIG. 37, an incision is made to expose the PIP joint 300. For example, FIG. 38 illustrates one example of the PIP joint 300 being exposed by using a cutting tool 400 having a blade 402.

At optional block 2004 (FIG. 37), the blade 402 of a cutting tool 400, such as a saw, is used to resect one or both of the adjacent faces of proximal phalange 302 and middle phalange 304 as illustrated in FIG. 39 The resected surfaces of proximal phalange 302 and middle phalange 304 can be debrided as understood by one skilled in the art.

At block 2006 (FIG. 37), bones are flexed apart and a first k-wire, pin, or other surgical device 10-1 is inserted into the proximal face of middle phalange 304. In some embodiments, the leading end 10A-1 of wire 10-1 is forced across the joint between middle phalange 304 and distal phalange 306, through distal phalange 306, and out the distal tip 306A of distal phalange 306 as shown in FIG. 40. The k-wire 10-1 continues to be advanced until the trailing end 10B-1 is disposed adjacent to the proximal face 304A of middle phalange 304 such that joint 300 is accessible. For example, the trailing end 10B-1 of wire 10-1 can extend slight from or be flush with the proximal face 304A of middle phalange 304. In some embodiments, trailing end 10B-1 is disposed entirely within middle phalange 304.

At block 2008 (FIG. 37), a second k-wire or pin 10-2 in inserted into the exposed distal face 302A of proximal phalange 302 while the first wire 10-1 is still disposed within middle phalange 304 and distal phalange 306 as shown in FIG. 41. In some embodiments, leading end 10A-2 of wire 10-2 is advanced such that it is disposed within proximal phalange 302. However, in some embodiments, leading end 10A-2 is further advanced such that it is received within metatarsal 310 and/or cuneiform (not shown).

At block 2010 (FIG. 37), implant 100A is driven into engagement with proximal phalange 302 as shown in FIG. 42A. In some embodiments, the implant 100A is driven into proximal phalange 302 using wire 10-2 as a guide. For example, the implant 100A is slid over trailing end 10B-2 of wire 10-2 by receiving wire 10-2 within passageway 101 of implant 100A. An installation tool, such as one of driver assembly 500 and/or installation kit 1030, including adapter 2600, can be used to engage the blade portion 104 of implant 100A and drive threaded portion 102 into middle phalange 302 as implant 100A is guided by wire 10-2.

At block 2012 (FIG. 37), second k-wire or pin 10-2 is removed from its engagement with implant 100A and proximal phalange 302 (and metatarsal 310 and cuneiform (not shown), if applicable). Implant 100A remains engaged with proximal phalange 302 once wire 10-2 has been removed as shown in FIG. 42B.

At block 2014 (FIG. 37), the middle phalange 304 is moved into engagement with implant 100A. For example, with wire 10-1 still disposed within middle and distal phalanges 304, 306, the middle and distal phalanges 304, 306 and wire 10-1 are manipulated such that the trailing end 10B-1 of wire 10-1 is aligned with the passageway 101 of implant 100A. In some embodiments, wire 10-1 can be inserted into passageway 101 prior to the middle phalange 304 being forced into engagement with the blade portion 104 of implant 100A as shown in FIG. 43.

At optional block 2016 (FIG. 37), end 10B-1 of k-wire 10-1 is advanced through proximal phalange 302, and into metatarsal 310 (and/or cuneiform (not shown)) as shown in FIG. 44.

At optional block 2018 (FIG. 37), what was initially leading end 10A-1 (FIGS. 40, 41, 42A, and 42B), is blunted or capped to provide an exposed blunt end 10C-1 as shown in FIG. 45.

At block 2020, after the surgical device 10-1 remains within a patient for a period of time, e.g., minutes, hours, days, or months, the surgical device 10-1 is removed to leave behind implant 100A as shown in FIG. 46.

Although the invention has been described in terms of exemplary embodiments, it is not limited thereto. Rather, the appended claims should be construed broadly, to include other variants and embodiments of the invention, which may be made by those skilled in the art without departing from the scope and range of equivalents of the invention.

Some embodiments provide an implant including an elongated threaded portion and a blade portion extending from the elongated threaded portion. The blade portion has a substantially cylindrical cross-sectional geometry and a taper defined by a plurality of blades.

Some embodiments provide an implant including an elongated threaded portion and a blade portion extending from the elongated threaded portion. The blade portion includes a plurality of blades having respective substantially cruciform cross-sectional geometries defined by a grooved portion being disposed in each quadrant of each blade.

Some embodiments provide a method including forming an incision to gain access to a joint between first and second bones, flexing the first and second bones such that the bones are disposed at an angle from one another, and advancing a threaded portion of an implant into the first bone. The implant includes a blade portion extending from an elongated threaded portion. The blade portion has a substantially cylindrical cross-sectional geometry and a taper defined by a plurality of blades. The method also includes repositioning the second bone such that a middle of the second bone is approximately aligned with the blade portion of the implant and forcing the second bone into engagement with the blade portion of the implant.

Although the invention has been described in terms of exemplary embodiments, it is not limited thereto. Rather, the appended claims should be construed broadly, to include other variants and embodiments of the invention, which can be made by those skilled in the art without departing from the scope and range of equivalents of the invention.

What is claimed is:

1. A method, comprising:

inserting a first surgical device into an exposed first end of a first bone until a trailing end of the first surgical device is disposed adjacent to the first end of the first bone;

inserting a second surgical device into an exposed first end of a second bone while the first surgical device remains disposed within the first bone;

advancing a first portion of an implant into the second bone while being engaged with a passageway defined by the implant such that the implant is guided by the second surgical device;

removing the second surgical device from the second bone and from its engagement with the implant;

repositioning the first bone such that the first surgical device is aligned with the passageway defined by the implant; and

forcing the first bone into engagement with a second portion of the implant.

2. The method of claim **1**, further comprising

forming an incision to gain access to a joint between the first bone and the second bone;

flexing the first bone relative to the second bone to expose the first end of the first bone and the first end of the second bone; and

resecting at least one of the first end of the first bone and the first and of the second bone.

3. The method of claim **1**, further comprising removing the first surgical device from the first bone and its engagement with the implant.

4. The method of claim **1**, wherein the passageway is a central passageway that extends through the entirety of the implant.

5. The method of claim **1**, wherein the first portion of the implant is a threaded portion and the second portion of the implant is a blade portion.

6. A method, comprising:

forming an incision to gain access to a joint between first and second bones;

flexing the first and second bones such that the first and second bones are disposed at an angle with respect to one another;

inserting a first surgical device into the first bone until a first end of the first surgical device is disposed adjacent to a first end of the first bone;

inserting a second surgical device into the second bone while the first surgical device remains disposed within the first bone;

advancing a first portion of an implant into the second bone while a passageway defined by the implant is engaged with the second surgical device such that the implant is guided by the second surgical device;

removing the second surgical device from the second bone and from its engagement with the implant;

repositioning the first bone such that the first surgical device is aligned with the passageway defined by the implant; and

forcing the first bone into engagement with a second portion of the implant.

7. The method of claim **6**, further comprising removing the first surgical device from the first bone and its engagement with the implant.

8. The method of claim **6**, further comprising resecting an end of each the first and second bones prior to inserting the first and second surgical devices.

9. The method of claim **6**, wherein the first bone is a middle phalange of a foot, and the second bone is a proximal phalange of the foot.

10. The method of claim **9**, wherein the first portion of the implant is a threaded portion and the second portion of the implant is a blade portion.

11. A surgical method, comprising:

gaining access to a joint between a middle phalange and a proximal phalange;

inserting a first end of a first surgical device into a proximal end of the middle phalange;

advancing the first surgical device into the middle phalange and a distal phalange until a second end of the first surgical device is disposed adjacent to the proximal end of the middle phalange;

inserting a first end of a second surgical device into a distal end of the proximal phalange while the first surgical device remains disposed within the middle and distal phalanges;

advancing a first portion of an implant into the proximal phalange using the second surgical device as a guide;

removing the second surgical device;

inserting the first surgical device into a passageway defined by the implant while the first surgical device remains disposed within the middle and distal phalange; and

removing the first surgical device from its engagement with the implant, middle phalange, and distal phalange.

12. The surgical method of claim **11**, further comprising:

advancing a second end of the first surgical device through the proximal phalange and into at least one of a metatarsal and a cuneiform; and

blunting the first end of the first surgical device.

13. The surgical method of claim **12**, further comprising, after a period of time, removing the first surgical device while the implant remains engaged with the proximal phalange and the middle phalange.

14. The surgical method of claim **11**, further comprising resecting an end of each the middle phalange and the proximal phalange prior to inserting the first and second surgical devices.

15. The surgical method of claim **11**, wherein the passageway is a central passageway that extends through the entirety of the implant.

16. The surgical method of claim **11**, wherein the first portion of the implant is a threaded portion and the second portion of the implant is a blade portion.

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